JOURNAL OF DAIRY SCIENCE

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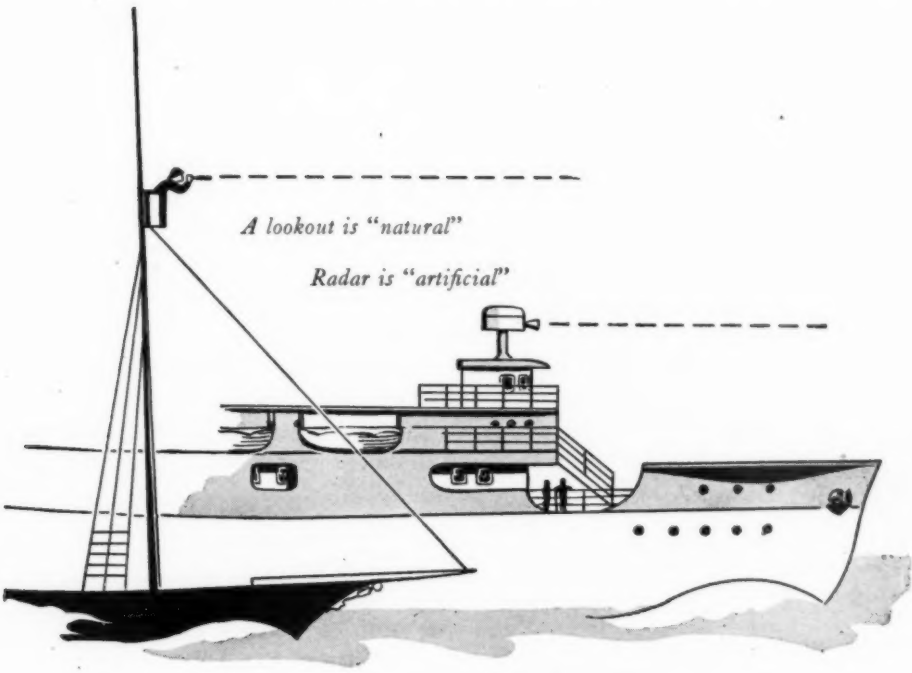

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VOLUME XXIX JULY, 1946 NUMBER 7

CLIPPING VS. GRAZING BY DAIRY HEIFERS AS MEANS OF ESTIMATING YIELD OF BLUEGRASS PASTURES[1, 2]

H. B. MORRISON AND FORDYCE ELY

Dairy Section, Kentucky Agricultural Experiment Station

In connection with a pasture experiment on the Experiment Station farm at Lexington, clippings were made at approximately two-week intervals throughout the grazing season from areas protected from grazing by wire cages. The estimated yield of total digestible nutrients (TDN) calculated from the amount of clippings obtained during five grazing seasons, 1940 to 1944 inclusive, is compared in this paper with that calculated from maintenance requirements and gain or loss in weight of dairy heifers grazing on the pasture.

EXPERIMENTAL CONDITIONS

The experiment pasture, consisting principally of Kentucky bluegrass (*Poa pratensis*) and white clover (*Trifolium repens*), was more than 25 years old. Alfalfa, red clover, alsike clover, sweet clover and Korean, Kobe and common lespedeza made up small portions of the flora. The pasture was comparatively free from weeds. Ragweed, dandelion, horsenettle, sourdock, buckhorn and yarrow were present, but in such small amounts as to contribute little to the herbage. The pasture had an area of 11.6 acres and its length was about twice its width.

No fertilizer was added to the pasture during this experiment except the droppings of the heifers. From time to time the droppings were scattered with a drag made from automobile tire rims chained together. Twice each year the pasture was clipped with a mowing machine, adjusted to cut about six inches above the soil level.

A total of 71 Jersey and 45 Holstein heifers were used in the five years

Received for publication March 21, 1946.

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by the permission of Thomas P. Cooper, Director of the Kentucky Agricultural Experiment Station in connection with Bankhead-Jones Project No. 6.

[2] The project was conducted cooperatively by the Dairy Section and the Agronomy Department. Yields of dry matter from which TDN in the harvested herbage was calculated were obtained by the Agronomy Department and are used with the permission of that department.

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of the experiment reported. The average age of the heifers when put in the pasture was 15 months and 2 days, and the average weight was 575 pounds. Starting ages ranged from 6 months and 13 days to 23 months, though 76 per cent of the heifers were between 10 and 12 months. Starting weights ranged from 229 to 1024 pounds, but 70 per cent of the heifers weighed between 400 and 750 pounds. Only heifers that appeared healthy were used.

Grazing was started as early in the spring and continued as late in the fall as seemed consistent with weather conditions and growth of grass. Heifers were conditioned to grazing by being on blue grass pasture about two weeks before experimental grazing was begun. During this period and while they were on the experimental pastures they had no supplemental feed except salt and sometimes bonemeal. The number of heifers on the pasture was varied in accordance with the judgment of the investigators and was based on the condition of the pasture, the weather, and the amount of weight gained or lost by the heifers during the preceding two-week period. An effort was made to keep the plots pastured up to their full capacity but not overgrazed. Grazing to full capacity was not possible during the period of most rapid growth of grass, usually May and June, when there were not enough heifers available. The maximum number of heifers on the 11.6 acres at one time was 22 and the minimum 4. The maximum weight of heifers on the pasture at one time was 15,929 pounds and the minimum 2239 pounds. Before being placed on pasture and at two-week intervals thereafter, each heifer was weighed on three consecutive days to obtain her average weight at that time. In case a heifer was in heat on one of the three weigh days the weight for that day was not used in determining the average weight because weights during estrus averaged somewhat below normal.

The total digestible nutrients obtained by the heifers from the pastures was calculated by the method of Morrison and Ely (11). By this method, 3.53 pounds of TDN were allowed per pound of gain and 2.73 pounds of TDN subtracted per pound loss in weight, as suggested by Knott, Hodgson and Ellington (9) and recommended by the Joint Pasture Committee (8). To calculate requirements the minimum amount of TDN advised by Morrison (10) for maintenance of dairy cows was applied to the average weight of all heifers on the pasture during the five seasons of this study. As Morrison's data are based only on cows weighing 700 pounds or more, amounts recommended by him for cows of various weights were plotted and the curve extended to obtain requirements of animals weighing 600 pounds or less.

TDN in clippings were calculated from yields of herbage harvested from 12 caged areas in representative parts of the pasture. Seventy-two per cent of the oven-dry matter was considered to be digestible (8). Each area contained 41.8 square feet. The areas were protected from grazing

by wire cages and harvested on approximately the dates when the heifers were weighed. Harvesting was done with a lawnmower set to cut the grass about one inch above the ground and the clippings were collected in a grass catcher attached to the mower. After each mowing, the cages were moved to new locations where the herbage was evenly grazed. The lawnmower was run over each area before the cage was placed.

RESULTS

In 1940, heifers were turned on the pasture April 12. Chart A of figure 1 shows the average daily yield of TDN throughout the season as calculated

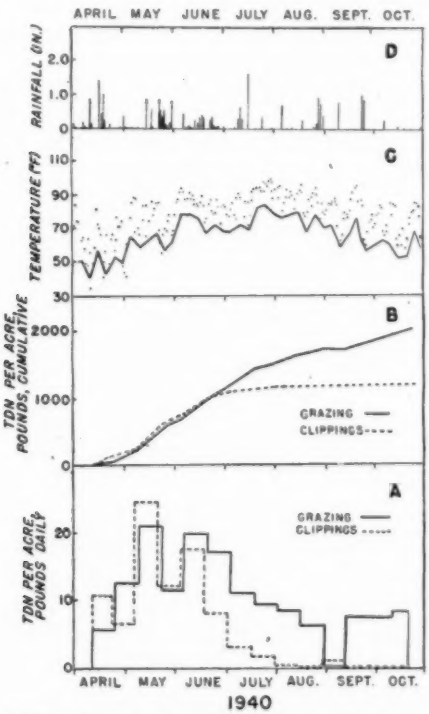

FIG. 1. TDN yields and weather conditions during the 1940 grazing season. A, daily production of TDN calculated from herbage yields and grazing data. B, accumulated production of TDN calculated from herbage yields and grazing data. C, maximum and average temperatures by 5-day periods. D, daily rainfall.

from clippings and from heifers weights. Chart B gives the cumulative total of TDN throughout the pasture season as calculated by the two methods. Chart C shows mean temperature from the records of the Lexington weather bureau station, averaged by 5-day periods, *e.g.*, the average

of the mean temperatures May 3 to 7 inclusive is plotted on May 5. Dots show the maximum temperature recorded each day. Chart D shows the inches of daily rainfall recorded by the Lexington weather bureau station.

The yield of TDN for the 1940 season calculated from clipping data was 1227 pounds or 59 per cent of that from grazing data (table 2 and fig. 1, B). Daily yields, as calculated from both clipping and grazing data (fig. 1, A)

TABLE 1

Summary of data on rainfall, temperature, and TDN calculated from herbage yields and grazing data

(Yields of TDN are stated as pounds per acre)

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total or ave.
1940									
Rainfall—inches	4.8	5.4	4.0	3.4	3.3	2.6	0.6	.....	24.1
Mean temp.—° F.	51.6	59.8	73.4	76.4	76.7	66.7	65.2	.....	67.1
TDN from clipping	181	518	398	97	13	17	3	.....	1227
TDN from grazing	138	504	516	358	222	135	204	.....	2077
1941									
Rainfall—inches	2.2	1.7	4.2	7.3	1.9	0.7	4.2	.....	22.2
Mean temp.—° F.	59.1	68.1	74.6	78.1	76.9	73.6	63.0	.....	70.5
TDN from clipping	146	213	195	217	68	41	9	.....	889
TDN from grazing	208	506	405	214	316	183	17	.....	1849
1942									
Rainfall—inches	3.1	3.4	5.5	8.2	7.3	3.0	3.5	.....	34.0
Mean temp.—° F.	57.6	64.6	74.4	78.2	75.5	67.4	58.0	.....	68.0
TDN from clipping	251	310	80	198	333	217	87	.....	1476
TDN from grazing	263	658	278	299	365	481	271	.....	2615
1943									
Rainfall—inches	4.0	6.7	3.1	7.7	1.1	1.9	1.6	.....	26.1
Mean temp.—° F.	50.8	66.4	78.0	77.6	78.5	67.4	56.9	.....	67.9
TDN from clipping	141	1009	543	138	203	39	3	.....	2076
TDN from grazing	62	507	633	397	250	335	96	.....	2280
1944									
Rainfall—inches	4.2	3.5	1.6	2.8	6.2	2.4	1.9	1.6	22.6
Mean temp.—° F.	53.8	70.9	77.5	77.7	79.9	67.4	56.1	43.8	69.0
TDN from clipping	254	758	168	34	322	496	174	12	2218
TDN from grazing	242	717	572	92	164	466	378	72	2703
5-year average									
Rainfall—inches	3.7	4.1	3.5	5.9	4.0	2.1	2.4	.....	25.7
Mean temp.—° F.	54.5	65.9	75.6	77.6	77.1	68.3	59.8	.....	68.3
TDN from clipping	195	562	277	137	188	162	55	2	1578
TDN from grazing	183	578	481	272	263	320	193	14	2305

reached a high peak during the middle two weeks of May and a secondary peak in June. Doubtless both peaks were caused primarily by the high rainfall in mid-April and late May (fig. 1, D). Following the middle of June, the TDN estimated from the clippings fell rapidly to a very low level and remained low during the rest of the season, probably because of relatively low rainfall. Yields of TDN calculated from grazing data, on the contrary, declined rather moderately in late June and were substantial after July 1, except during early September. The estimates of accumulated

pasture production in 1940 by the two methods parallel each other quite closely until late in June after which yields calculated from clippings were substantially lower than those calculated from grazing data (fig. 1, B).

During the 1941 season the total yield of TDN calculated from clipping data was 889 pounds or 48 per cent of that calculated from grazing (table 2 and fig. 2, B). The highest yield from clipping was in late April and

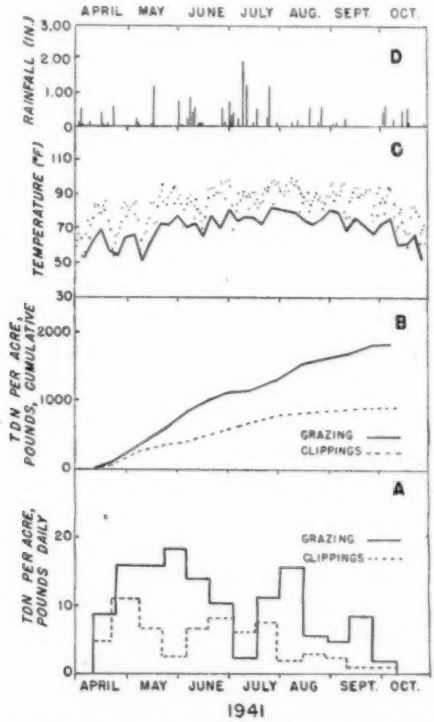

FIG. 2. TDN yields and weather conditions during the 1941 grazing season. A, daily production of TDN calculated from herbage yields and grazing data. B, accumulated production of TDN calculated from herbage yields and grazing data. C, maximum and average temperatures by 5-day periods. D, daily rainfall.

early May. Lesser peaks of yield occurred in late June and July in response doubtless to the above-average rainfall in those months. Yields of TDN estimated from grazing data in April were much higher than those from clippings. Peak yields occurred in late May and early June, August and September (fig. 2, A). Yields of TDN as calculated by both methods accumulated at similar rates until late June. Thereafter those obtained from grazing continued to increase while those from clippings increased but

slightly. Doubtless the relatively low yields of TDN obtained in 1941 are correlated with the somewhat deficient rainfall of the season and the relatively high temperature (table 1).

The estimated yields of TDN from clipping and grazing in 1942 had similar trends throughout the season, although that calculated from clipping data (1476 pounds) was only 56 per cent of that calculated from grazing (table 2 and fig. 3, B). Yields from clipping were high in April and somewhat higher in early May. They dropped rapidly until mid-June and then rose to their highest figure of the year in August. They dropped again slightly in mid-August and after a slight rise in September were low during the rest of the season. Yields calculated from the grazing data reached a much higher peak in May than that from clipping, dropped to a low point in mid-June and then steadily increased to a secondary high point in late

TABLE 2

TDN calculated from herbage yields and grazing data

Year	No. of days in each season	TDN from clipping		TDN from grazing		Clipping yield on basis of grazing yield as 100
		Total per acre	Per acre per day	Total per acre	Per acre per day	
		pounds	*pounds*	*pounds*	*pounds*	
1940	196	1227	6.26	2077	10.60	59.1
1941	182	889	4.88	1849	10.16	48.1
1942	210	1476	7.03	2615	12.45	56.4
1943	168	2076	12.36	2280	13.57	91.1
1944	210	2218	10.56	2703	12.87	82.1
Ave.	193.2	1578	8.16	2305	11.93	68.5

September. Yields of herbage as calculated from grazing and clipping accumulated at somewhat similar rates throughout the whole season (fig. 3, B). Rainfall in 1942 was higher than in any of the other seasons in this 5-year period (table 1). It was especially high in July and August, resulting in much growth of herbage from July to October. Monthly mean temperatures during the 1942 season were all very close to the 5-year average (table 1). The maximum temperature recorded during the grazing season was 98 degrees F. and temperatures of 90 degrees F. or higher were recorded on 42 days.

Total yields of TDN in 1943 estimated by the two methods (table 2 and fig. 2, B) were approximately equal, those calculated from clipping being only 9 per cent less than grazing. The slope of the curve expressing yield from clipping, however, was much steeper during the first two months and less steep during the last four months of the grazing season than that based upon grazing data. In the early part of the 1943 grazing season the TDN yield estimated from clipping reaching the highest point during this 5-year period (fig. 4, A). It averaged nearly 38 pounds daily per acre from May 7 to May 21. During the 53 days from April 26 to June 18 it averaged

slightly over 30 pounds daily. It then dropped to a comparatively low level and remained rather low for the rest of the season. The estimated yield from the grazing data did not reach nearly so high a level as did that from the clipping but remained much more constant throughout the season. The high yield occurred late in May and remained fairly constant until

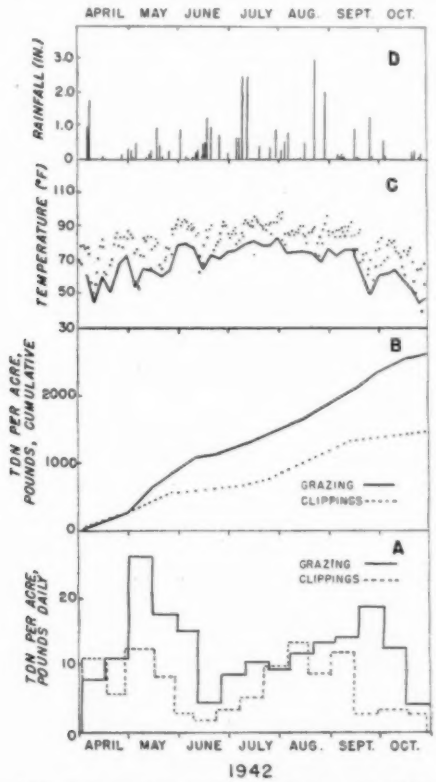

FIG. 3. TDN yields and weather conditions during the 1942 grazing season. A, daily production of TDN calculated from herbage yields and grazing data. B, accumulated production of TDN calculated from herbage yields and grazing data. C, maximum and average temperatures by 5-day periods. D, daily rainfall.

mid-July. After four weeks at a low level it again rose to an average of more than 10 pounds of TDN daily and remained essentially constant during the rest of the season. Doubtless the very high yields of TDN produced before mid-July were correlated with the very high rainfall of 21 inches that fell between April 1 and August 1 (table 1). After August 1, there were only two dates on which more than one-half inch of rain was recorded.

Monthly mean temperatures were not greatly different from the 5-year average but an unusual maximum temperature of 102 degrees F. was recorded in August and 12 of the 22 days when the temperature reached 95 degrees F. or higher were in August. Temperatures of 90 degrees F. or higher were recorded on 56 days in 1943 (fig. 4, C).

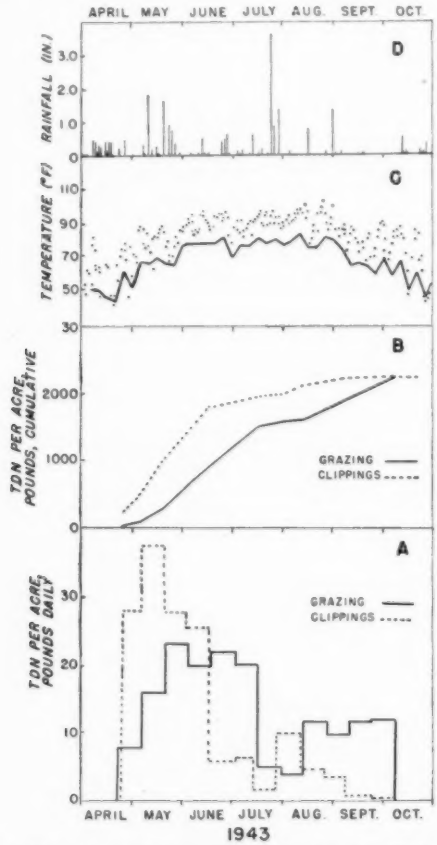

FIG. 4. TDN yields and weather conditions during the 1943 grazing season. A, daily production of TDN calculated from herbage yields and grazing data. B, accumulated production of TDN calculated from herbage yields and grazing data. C, maximum and average temperatures by 5-day periods. D, daily rainfall.

Total yield of TDN in 1944 estimated by the grazing method exceeded that obtained from clippings by 485 pounds per acre, or about 18 per cent. Accumulated yields by both methods were similar throughout the season of 1944 (table 2 and fig. 5, B). Two quite high peaks of production with a

period of very low production between them are shown by both methods of measurement (fig. 5, A). High production of TDN, as calculated from clipping, occurred early in May. Thereafter there was a decline in production until late in June. Production again rose rapidly from early August to early September and then dropped steadily until the end of the season. Highest production as estimated from grazing also occurred in

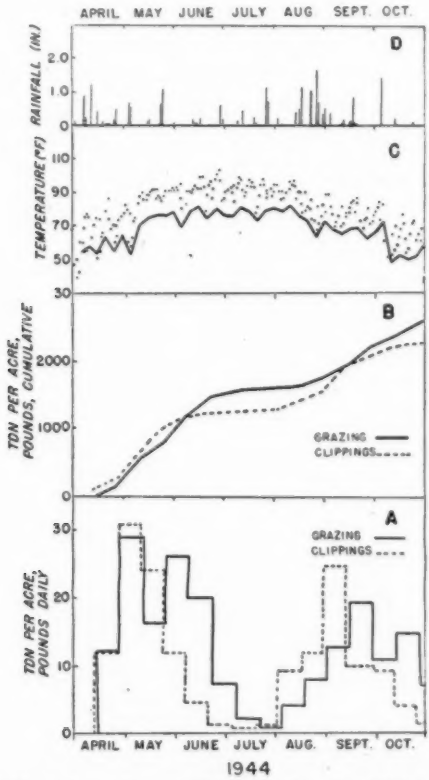

FIG. 5. TDN yields and weather conditions during the 1944 grazing season. A, daily production of TDN calculated from herbage yields and grazing data. B, accumulated production of TDN calculated from herbage yields and grazing data. C, maximum and average temperatures by 5-day periods. D, daily rainfall.

early May and production remained high until about June 1. Low production occurred in July and another period of high production late in September.

The curves of chart B, figure 5, show that the accumulated yields of TDN in 1944 as calculated by the two methods paralleled each other rather closely

throughout the season. Doubtless the patterns of TDN yield curves in charts A and B were correlated with the good rainfall during April and May, the drouth in June and July, and the large amount of rainfall in August. Somewhat higher than average temperatures during June, July and August may have contributed to the low yields produced between mid-June and mid-August. The highest temperature of the season was 103

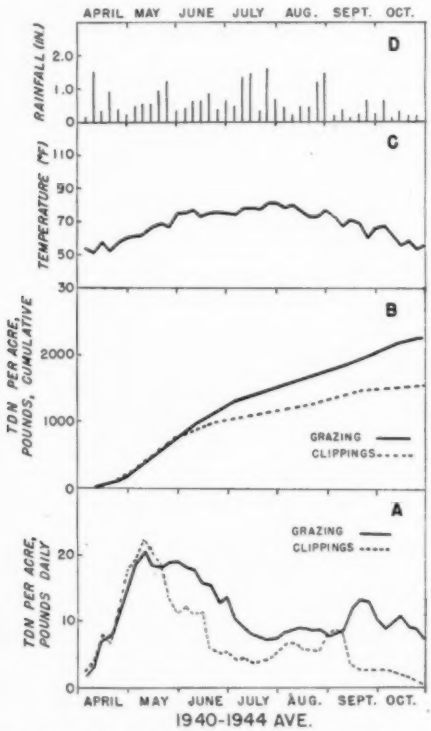

FIG. 6. Average TDN yield and weather conditions 1940–1944. A, average daily production of TDN calculated from herbage yields and grazing data. B, average accumulated production of TDN calculated from herbage yields and grazing data. C, average temperature by 5-day periods. D, average rainfall by 5-day periods.

degrees F. on June 28. There were 66 days on which temperatures of 90 degrees F. or higher were recorded, 22 of these being in June and 21 in July.

A 5-day moving average of calculated TDN yields produced throughout the season during the 5-year period shows by both methods of calculation a peak in production on about May 11 (fig. 6, A). The yield calculated from clipping was slightly higher than that from grazing at that date, but about 10 days later the yield calculated from grazing became higher and remained

in that relative position during the rest of the season except during a few days in early September. The 5-day average cumulative yield of TDN calculated from clipping was slightly higher than that calculated from the data on grazing by heifers up to June 1, but after that date the grazing data indicate the higher yield (fig. 6, A). The average total annual yield estimated from clipping was 1578 pounds per acre, or about 68 per cent of that from grazing (table 2). For comparison the average temperatures for the 5 grazing seasons are given by 5-day periods in table 1 and fig. 6, C, and the average daily rainfall is shown in fig. 6, D. Monthly and seasonal rainfall and monthly and seasonal mean temperature are shown on table 1.

DISCUSSION

Under the conditions of this experiment with Kentucky bluegrass pasture, the average yield of TDN calculated from grazing data agreed fairly well with that calculated from clipping the herbage during the spring. During the remainder of the season the yields calculated from grazing data were larger than those calculated from clippings. Yields of TDN calculated from clippings in the 5 years of this experiment ranged from 48.1 to 91.1 per cent (average 68.5 per cent) as large as those from grazing. Considerably less variation occurred from season to season in the yields estimated from grazing data than in the estimates from clippings. By both methods of measurement highest yields were obtained in 1944 and lowest yields in 1941. Yield in 1940 was next to the lowest. The order of yields obtained in 1942 and 1943 is reversed by the two methods of calculation.

Results of this experiment are not in agreement with those obtained by several other investigators (1, 3, 4, 5, 6, 7,) who found that the yield of TDN estimated from clippings usually exceeded that calculated from grazing. Robinson, Pierre and Ackerman (12) reported that grazing indicated higher yields in four out of five years. However, these reports dealt with many kinds of pasture grasses and legumes and different grasses and legumes are adapted to different techniques in clipping and pasturing (2, 8). In the case of bluegrass, a small number of animals can be placed on the pasture as soon as the grass starts growing actively in the spring and the number can be increased as the growth indicates that a larger number can be supported. Furthermore, bluegrass can be grazed rather close during the entire season. On the other hand, some pasture crops must be permitted to attain considerable growth before pasturing and many cannot be grazed as close throughout the season. Such pasture crops are not likely to be fully utilized by grazing, and it would appear, therefore, that yields of TDN obtained by clippings would be higher than those calculated from grazing data.

In calculating pasture yield in terms of TDN in this experiment the amount of TDN allowed for maintenance plus gain was slightly higher than

the amount allowed by some investigators (12) when gains of heifers were about one pound daily; but when gains of two or more pounds daily were made by heifers, the amounts of TDN allowed for maintenance plus gain in this experiment were considerably higher than allowed by the method used by Robinson *et al.* (12). In many of the comparisons of methods of measuring pasture yields by other investigators milking cows have been used as experimental animals. Usually the milking cows have had supplementary feeding, which presumably would cause them to eat less grass than animals which receive no feed other than pasture.

As might be expected, the curves of grazing yield obtained in this experiment show increases and decreases in calculated yield of TDN from grazing to occur one to two weeks later than from clipping. Grazing yields are not quite as high as clipping yields in the spring when the growth of grass is most rapid, but the heifers were able to utilize the excess grass a little later when the growth of grass had slowed down. Doubtless the lag might have been cut down somewhat if more heifers had been available for the experiment, but even so, the pasture carried an average of almost two heifers per acre during the periods of most rapid growth of grass. Later in the season the trends of curves of the 5-year average yields from clipping and from grazing follow each other quite closely, but the curve for grazing is somewhat higher and changes about two weeks after the change indicated by clipping.

The method of obtaining clippings used in this study, in which the cages were moved at two-week intervals to rather close-grazed areas, may give somewhat low results especially during periods of slow growth. Especially during drouths there were times when many of the leaves of grass on the new locations for the cages were below the level at which the lawnmower cuts. The clippings obtained at the end of the following two-week period, therefore, may have been somewhat less than the actual growth during the period.

In estimating the yield of pasture, or its value as a source of feed for cattle, it is axiomatic that the effective yield of pasturage can be measured only by grazing. However, when it is not practicable to measure yield of Kentucky bluegrass pasture by animals, clipping protected areas as done in this experiment is a reasonably accurate method for determining relative yield.

SUMMARY

Yield of a Kentucky bluegrass pasture in terms of TDN per acre was calculated from clipping with a lawnmower and from grazing with dairy heifers during five seasons, 1940–1944 inclusive, the grazing season ranged from 168 to 210 days in length.

Yield calculated from grazing was higher than that calculated from clipping in each of the five seasons. The calculations from clipping were 50.1,

48.1, 56.4, 91.1, and 82.1 per cent of those from grazing in 1940, 1941, 1942, 1943 and 1944, respectively. The average calculated yield from clipping was 68.5 per cent of that from grazing.

The maximum, minimum and average yields of TDN calculated from clipping were 2218, 889 and 1578 pounds per acre respectively, and from grazing 2615, 1849 and 2305 pounds.

The average daily amount of TDN furnished by the pasture for an entire season ranged from 4.88 pounds to 12.36 pounds per acre as calculated from clipping, and from 10.16 pounds to 13.59 pounds as calculated from grazing.

The trend of the curves representing calculated yield obtained by clipping and grazing with heifers were in general quite similar, although a pronounced change in yield usually occurred in the grazing curve two to three weeks later than in the clipping curve.

The data obtained in this experiment indicate that the clipping method of measurement may be used in a preliminary way to evaluate variables in experimental management of Kentucky Bluegrass pastures.

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A SYNTHETIC PABULUM FOR THE PRESERVATION OF BULL SEMEN[1]

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The yolk-buffer pabulum for the preservation of bull sperm (1, 2) was developed to meet practical conditions of artificial insemination. An attempt was made to provide a sufficiently favorable environment to maintain the virility of the sperm for periods up to 96 hours or more. In the first full report (2) data were available to show that cows could be bred with semen 100 hours old. From these data it seemed that it would be possible to have on hand a usable semen sample from any given bull every day of the month. In actual practice this goal has not been attained.

Various attempts have since been made to improve yolk-buffer as a storage pabulum for bull sperm. Knoop (3) presented evidence to show that the addition of small amounts of gelatin added to yolk buffer lengthened the interval that bull sperm could be stored. Later Knoop and Krauss (4) reported that diluents containing 1.0 per cent glycine, or 1 per cent *l*-proline and without gelatin were superior to egg-yolk-buffer-gelatin, for sperm survival. The inference was that these amino acids were the active ingredients responsible for the gelatin stimulation. Salisbury, Fuller and Willett (5) substituted sodium citrate for the dibasic sodium phosphate of the Phillips formula and obtained better visibility of individual spermatozoa in the resulting mixture since the citrate caused a noticeable dispersion of the fat globules of the egg yolk.

Phillips and Lardy (2) in 1940 and again in 1942 (6) called attention to the resistance of yolk-buffered bull semen to cold shock. This observation was confirmed and extended by Lasley, Easley and Bogart in 1942 (6). Mayer and Lasley (7) reported the preparation of a "resistance factor" in egg-yolk which was an acetone, alcohol ether-insoluble crystal-like substance giving a positive ninhydrin reaction. The authors report this substance to be active in a ratio of 1:250. Lardy and Phillips (8) presented evidence in 1942 to show that the addition to yolk-buffered bull semen of glucose, glucose and dibasic sodium phosphate, or dibasic-sodium-phosphate-glucose and adenylic acid prolonged active motility over that obtained with yolk-buffered semen only. By far the greatest stimulation was obtained in the combination wherein glucose and adenylic acid were used. This led

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to the suggestion that the loss of motility may be the result of loss of dialyzable coenzymes.

We have previously pointed out that bull sperm obtained their energy from two sources, phospholipids (acetone-insoluble proportion of egg yolk, or soybean lecithin) and glucose, that their energy was obtained by one of two mechanisms, oxidation or glycolysis (9, 10) and when oxidation and glycolysis are inhibited, a limited degree of motility is supported by some other means (probably reserve high energy phosphate) (11). Salisbury and Vandemark (12) presented evidence to show that small amounts of glucose added to egg yolk citrate increased the livability and lactic acid production of bovine semen. These authors state that "the glucose loss was not directly related to the livability of the spermatozoa unless that sugar was glycolyzed to lactic acid." This confirms the report of Lardy and Phillips in 1941 (9) when they showed that "added sugars maintained motility only if they could be catabolized to lactic acid by the spermatozoa."

Despite these data field inseminations show that yolk-buffered semen (alone and in its various modified forms) continues to be used before the end of 72 hours. The opinion prevails that the "mine-run" sample of yolk-buffered semen is not dependable beyond this period. While this opinion is not fully supported by our laboratory data it is recognized that there is a progressive loss of metabolic activity, motility and vitality which results in lowered breeding performance somewhere between the 60th and 125th hours of storage. The success and extent of artificial insemination as an instrument for cattle improvement depends upon how successfully bull sperm for breeding purposes can be stored and preserved.

The present report deals with a considerable number of observations pertinent to the storage of bovine semen and which have made possible the development of a synthetic pabulum for bovine semen storage.

EXPERIMENTAL

The experiments herein reported were designed to study the effects of certain proteins, lipids and carbohydrates or their metabolic intermediates upon bull spermatozoa storage. Further, the effects of certain gums or bactericidal agents were also investigated. These constituents were studied singly or in various combinations, and their ability to environ sperm was measured against control aliquots of bull sperm stored as yolk-buffered semen. In all cases the storage interval was used as the measure of adequacy of the storage pabulum and the end point used was the time when a clear-cut demonstration was evident in the superiority or inferiority of the storage medium.

The samples were rated on the basis of their motility. A value of 5+ was given the best samples and 1+ for the poor samples. The rating was made when there was no longer distinctly active motility and when ap-

proximately ¾ of the sperm were immobilized. Because of the variation between experiments each experiment carried its own yolk-buffered sample as a standard of comparison. The sperm samples were checked daily in duplicate under the microscope at 30° C. and motility ratings made and recorded. When a single sample reached a 1+ motility on duplicate observations the entire experiment was terminated. In order to conserve space summarizing tables were made which give only the experiment number, the terminal motility rating for each experimental treatment and the time required to reach the motility ratings. Thus by noting the total length of the storage period in hours under any given experimental treatment a comparison of the effect of the environmental pabulum upon motility in storage could be made.

Unless otherwise stated, buffer concentrations were 0.15 M. This conforms to our previously established optimal molarity. The buffer salts employed were mono-basic potassium phosphate and dibasic sodium phosphate in amounts sufficient to give a final pH of 6.8–7.0 for the respective mixture. The other constituents were varied as indicated. All samples were stored in the refrigerator at 4–5° C. The lipositol used in these experiments was made according to the method outlined by Woolley (14). Lecithin was purified by two extractions each of alcohol and acetone with constant stirring at room temperature. The lipoid fraction must be used fresh or stored under conditions which eliminate hydrolysis. Slightly hydrolyzed lecithin or lipositol gave very inferior results. Both preparations were used after 2 to 3 months storage in the refrigerator at 5° C.

RESULTS

The data presented in table 1 were selected from different experiments and are typical of the results obtained. In all cases the experiments were repeated two or more times and many were checked by as many as 10 repeat experiments with different semen samples from the same or different bulls. In these experiments the amino acid arginine, or the protein of blood fibrin was without stimulatory effect upon storage. Inspection of the data indicate that purified lecithin or lipositol preparations from crude soybean lecithin when used to replace the yolk component of yolk-buffer in the presence of 0.04 M glucose, or a mixture of galactose (0.02 M) and glucose (0.04 M) was equal to and in most cases superior to yolk-buffer as a storage medium for bull sperm. Glucose added to yolk buffer improved the storage medium but not uniformly so. Favorable concentrations of the glucose additions to yolk buffer were found to be 0.02 to 0.04 M. Individual components of lipositol, such as tartaric acid and with the exception of inositol were without stimulatory effect. Inositol when properly buffered and with added glucose and galactose promoted excellent motility for prolonged periods. The optimum concentrations of inositol were found to be 0.05 to 0.01 M solutions.

In an attempt to determine the action of certain sperm inhibitors it was observed by Phillips and Lardy (13) that certain gums noticeably reduced the inhibitory action. It seemed from this that the use of certain of the commercial gums might be beneficial to sperm storage. Table 2 indicates the effect of these gums upon sperm survival. Each of these experiments was repeated from two to four times. It is evident that gum damar and guaiac were definitely toxic while gum arabic, acacia, mesquite, ghatti and

TABLE 1

Data of selected experiments which show the influence of certain factors upon bull spermatozoa preservation

Treatment of semen	Data from experiment No.	Semen evaluation after storage	
		Rating	Hours stored
YB only (control)	1	1+	96
YB + arginine (1½ mg. in 5 cc.)	1	1+	96
YB only (control)	2	1+	96
YB + blood fibrin (0.5%)	2	1+	96
YB only (control)	3	1+	96
Lecithin prep. + 0.04 M glucose (buffered pH 7.8)	3	2+	96
YB only	5	1+	168
YB only (control)	8	fm*	96
YB + 0.04 M glucose	5	2+	168
YB + 0.04 M glucose	8	fm	96
YB + 0.04 M galactose	8	fm	96
Lecithin prep. + 0.04 M glucose	8	1+	96
Lecithin prep. + 0.04 M glucose + 0.02 M galactose	8	2+	96
Lecithin prep. + 0.04 M galactose	20	2+	96
Lipositol + 0.04 M glucose + 0.04 M galactose	20	2+	96
Galactose + glucose + tartaric acid	8	fm	96
Pure inositol + galactose + glucose + tartaric acid	8	1+	96
YB only (control)	8	fm	96
Inositol + 0.04 M glucose	8	1+	96
YB only (control)	17	2+	96
Tragacanth, lecithin-buffer-glucose	17	2+	96
Buffer-glucose-lecithin	17	1+	96
Gum-buffer-glucose-lipositol	26	1+	168
Gum-buffer-glucose-lecithin	26	1+	168

* fm = few motile.

tragacanth were not harmful. Each of these gums was helpful in that they formed sufficient body to prevent the settling out of sperm upon standing in storage. The concentrations which were found to be desirable and which were used in the later experiments were acacia 2 to 3 per cent, mesquite, arabic and ghatti 2 per cent, and tragacanth 0.5 to 1.0 per cent.

Since experiment 8 indicated that tartaric acid was not toxic to sperm an experiment was made to determine if other dicarboxylic acids were stimulatory to sperm in storage. The basic formula used as a control in this experiment was the same as that indicated in table 2.

TABLE 2

Data on effect of certain gums upon bull sperm storage

Gum†	Data from experiment No.	Semen evaluation after storage	
		Rating	Hours stored
Buffer solution only	16	1+	48
Buffer-tragacanth	16	fm*	48
Buffer-tragacanth-lecithin	17	1+	144
YB (control)	17	1+	144
Tragacanth	21	1+	168
Mesquite	21	1+	168
Arabic	21	2+	168
Damar	21	0	24
Guaiac	21	0	24
Ghatti	21	1–2	168
Acacia	21	1+	168
YB + 0.04 M glucose	21	1+	168

* fm = few motile.

† Basic formula used to test action of gums.

Glucose	0.6%
Galactose	0.2%
KH_2PO_4	0.2%
$Na_2HPO_4 12H_2O$	1.8%
Lipositol	1.0%

It is evident that the dicarboxylic acids tested are not capable of sustaining motility in storage. The slight beneficial effect of adipic acid was not confirmed in subsequent tests. Tartaric acid, pimelic and adipic acid additions to the base alone gave 5+, 5+ and 3+ motility, respectively, at 48 hours.

Because of the flagrant growth of bacteria in some of the combinations used in these experiments and whereas we had found in 1943 (13) that cer-

TABLE 3

Data on the effect of certain dicarboxylic acids upon bull spermatozoa survival

Acid added—basic formula as previously used	Semen evaluation after storage	
	Rating	Hours stored
Base + lipositol + glutamic acid, 0.01 M	1+	24
Base + aspartic acid, 0.01 M	1+ (many club tailed)	24
Base + tartaric acid, 0.01 M	1+*	72
Base + succinic acid, 0.01 M	1+*	72
Base + malic acid, 0.01 M	1+	72
Base + citric acid, 0.01 M	1+	72
Base + glutaric acid, 0.01 M	1+*	48
Base + adipic acid, 0.01 M	3+	48
Base + pimelic acid, 0.01 M	3+	48
Base + lipositol control	4+	72
Base + lipositol + adipic acid, 0.01 M	3+	72

* Heavy bacterial growth observed.

tain antibiotics including penicillin were not harmful to bull sperm motility, a series of experiments were then made to determine the effect of certain sulfonamides, penicillin, and streptomycin upon sperm storage. The base used in these experiments was that previously indicated plus three per cent gum acacia. The results are shown in table 4. It is apparent that sulfapyridine was definitely toxic and that certain of the sulfonamides and streptomycin did not impair sperm motility in storage. Sulfasuxidine, sulfathalidine, sulfaguanidine and streptomycin appeared to favorably influence the maintenance of motility. This action was particularly noticeable in some samples of semen. Apparently gross bacterial contamination was sufficient to seriously curtail survival of sperm in these cases and the antibiotic action of these drugs was therefore beneficial.

TABLE 4

Data on the effect of antibiotics on sperm storage

Drug used	Data from experiment No.	Semen evaluation after storage			
		Rating	Hours stored	Rating*	Hours stored
Base only (control)	28	3	96	1+	168
Base + sulfathiazole (30 mg.%)	28	3+	96	vfm	168
Base + sulfadiazine (30 mg.%)	28	4+	96	vfm	168
Base + sulfapyridine (30 mg.%)	28	1+	96	vfm	168
Base + sulfaguanidine (30 mg.%)	28	3+	96	2	168
Base + sulfasuxidine (30 mg.%)	28	4+	96	1	168
Base + sulfathalidine (30 mg.%)	28	4+	96	2	168
Base + sulfathiazole (30 mg.%)	29	3+	120	vfm	144
Base + sulfathiazole + Lasley prep.	29	3+	120	fm	144
Base + Lasley prep.	29	4	120	fm	144
Base + streptomycin	29	2	168	1+	192
Base + sulfasuxidine	29	2	168	1+	192
Base + sulfathalidine	29	1	168	1+	192
Base only (control)	29	1	168	fm	192

* fm = few motile.
vfm = very few motile.

On the basis of the foregoing results a synthetic bull sperm pabulum was developed for the purpose of environing them for storage purposes. This pabulum was made up as indicated below. It possesses an outstanding advantage in that each individual sperm is easily discernible under all powers of the microscope. Its essential ingredients include a lipid fraction, carbohydrate, buffer salts and a gum to give the proper physical consistency. As a routine measure it is suggested that sulfathalidine, sulfasuxidine or streptomycin be added to this pabulum at the rate of 25–30 mg. per 100 ml.

In this formula glucose can be used as the only sugar but frequently the results are improved by the addition of traces of galactose. Lipositol made after the method of Woolley (14) or highly purified soybean lecithin

Lipid-glucose-buffer-gum (LGB)

Glucose	0.6	per cent
Galactose	0.2	"
KH_2PO_4	0.2	"
$Na_2HPO_412H_2O$	2.0	"
Lipositol, or purified lecithin	1–2.0	"
Gum acacia	3.0	"
Distilled H_2O to volume		
Sulfathalidine, sulfasuxidine or streptomycin	0.03	"

can be used as the source of the lipid. Such preparation should be freshly prepared or stored under conditions to prevent deterioration. Any of the forementioned gums may be used as desired although commercial gum acacia seemed to be one of the most desirable ones. An initial pH of 6.9 with this mixture seemed to be near optimum.

Field tests with similarly compounded dilutors, that is bases which contained glucose-galactose, lipid, gum acacia and buffer gave results comparable to yolk-buffered semen. The field results with semen largely under 36 hours in storage and under actual breeding conditions in October, 1945, gave the following:[2]

Yolk buffer semen—140 cows bred—62 fertile inseminations
L.G.B. —138 " " —65 " "

LGB can be mixed by weighing out the glucose buffer salts, lipid and gum and adding the approximate amount of distilled H_2O. Boil gently and add the antibiotic if desired. Considerable latitude in the method of making up this formula is allowable. The molarity of the solution with respect to the buffer and sugar proportions seems to lie within very narrow limits and little latitude is allowable here.

SUMMARY

The data presented suggest the following pertinent facts in relation to the storage of bull semen.

The addition of blood-fibrin, or arginine, were without measureable effect upon motility of sperm. Glucose additions in concentrations of 0.02 to 0.04 M improved in most cases the storage of bull semen environed in egg yolk-buffer. Freshly purified lecithin, or lipositol from crude soybean lecithin free of free fats or fatty acids with 0.04 M glucose, or with a mixture of 0.02 M galactose and 0.04 M glucose provided a highly effective pabulum for the storage of the sperm. In many experiments a combination of galactose and glucose (conc. indicated above) was superior to glucose alone. Inositol in 0.05 to 0.1 M solutions and in combination with glucose and galactose likewise benefited sperm motility. The addition of certain gums was beneficial while gum damar and gum guaiac were definitely toxic.

[2] We are indebted to Dr. L. E. Casida and Mr. Geo. R. Barrett for making pregnancy diagnoses on these cows.

Certain antibiotics as well as certain of the sulfonamides were effective in controlling bacterial growth without impairment of sperm survival.

On the basis of these data a synthetic pabulum for bull sperm storage may be used. Its essential ingredients should include freshly purified lipids, specific sugars—glucose and galactose, a buffer system, a gum to supply the proper physical consistency and an agent to control bacterial contamination.

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TIME REQUIRED FOR MAKING FLAVOR JUDGMENTS OF MILK[1]

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Flavor is the major item generally evaluated in the judging of dairy products. In arriving at a flavor evaluation the judge first smells and tastes the sample and then compares the sensations noted with mental concepts of desired standards. This evaluation of flavor naturally takes some time. However, the actual time required by the experienced judge to ascertain the taste of a sample is surprisingly short. Such a judge has come to realize that the taste-reaction time not only varies with different "tastes" but also that it is fixed within certain ranges for specific tastes. Sometimes the experienced judge finds it necessary to retaste a sample, but often judgment is passed on the basis of the one taste-reaction.

Unfortunately, inexperienced judges are not appreciative of the "quickness" of taste reactions or of the sequence of sensory reactions specific to certain flavors. Consequently, the inexperienced judge may not be "in readiness," and, therefore, may miss entirely, or at least ignore, the first taste reaction. As a result, he may taste a sample repeatedly, making little progress toward final judgment. Thus, he tends to waste the precious first moments of tasting. Meanwhile, the onset of taste adaptation may make it more difficult for the beginner to diagnose correctly the often delicate, first taste sensation of the product. As a result he may tend to lose confidence in his judging ability. If he has 10 or more samples to judge at one time, he may be inclined to think that this inability to sense the taste reaction is an indication of satiation or of dulled taste sensitivity. Actually, the experienced judge, knowing when to expect taste reactions, will taste scores of samples before fatigue is experienced.

While many data have been reported on the taste-reaction time of substances in aqueous solutions yielding the fundamental tastes of sweet, sour, salt, and bitter, no such data on the flavors of milk were known to be available. Such information would appear to be of value as an aid in developing alertness in beginners in the judging of milk and for instilling greater confidence in the experienced judge. To this end data were secured in this study.

PROCEDURE

In the routine scoring of milk for flavor the opportunity presented itself for a study of the time required to place judgment on the samples. By means of a stop watch in the hands of an observer, the elapsed time from

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the introduction of the sample into the mouth until the taster signalled recognition of the flavor, was noted. While this method did not yield split-second accuracy, it did give a very good indication of the elapsed time from exposure of the sapid substance to recognition of the taste reaction, which was the desired aim.

In the majority of cases approximately 125 samples were judged at one sitting; in some instances, over 300 samples were tasted at one tasting period.

The milk consisted both of individual cow and mixed herd samples. Each sample was divided into three portions, one of which was untreated, one holder pasteurized without copper contamination, and one similarly pasteurized, but had added 0.25 ppm. of copper after pasteurization. The samples were judged at 60° F. after storing 3 and 7 days at 40° F. The identity of the samples was not known to the judge at the time of judging. All recordings were made by a second party.

Generally, only one tasting was necessary to arrive at a judgment, but in several instances when the taste reaction was not pronounced, a second or third taste was made.

The mouth was not rinsed out between samples except when an especially pronounced nauseating flavor was experienced; then tepid water was used as a rinse.

Tasting was done continuously from the start with only occasional minor interruptions. There were no rest periods following tasting of each sample or after tasting a group of samples.

RESULTS

Time recordings were taken on the judging of 2262 samples of milk for flavor. Over one-half of them rated an excellent flavor with no criticism. Interspersed were samples having "cheesy," "flat," "high-acid," "oxidized," "rancid" and "salty" flavors, the percentage distribution of which is shown in table 1.

Definite differences were noted in the average time required to recognize the various flavors in milk (table 2). For example, of the flavors observed, the judgment time of "salty" milk was found to be the least of all, being 2.9 seconds. On the other hand, more time was required to pass judgment on excellent flavor milk than on milk having various off-flavors. The order of the flavor, so far as time required to pass judgment on them is concerned, was as follows: "salty," "cheesy," "high-acid," "rancid," "flat," oxidized," "excellent."

The comparative long time required to pass judgment on excellent flavor milk may be explained by the very nature of the flavor. When off-flavors are present the taste-reaction may be noted quickly whereas in the absence of an off-flavor there is the waiting period for a possible off-flavor taste reaction and probable retasting to check the taste reaction. These average

TABLE 1

The distribution of flavors noted in 2262 samples of milk tasted

Flavor	Distribution of milk samples having specific flavors			
	Number		Per cent	
Excellent	.....	1222	.....	54.0
Cheesy	.....	10	.....	0.4
Slightly	4	.....	0.1	.....
Distinctly	6	.....	0.3	.....
Flat	.....	73	.....	3.2
High-acid	.....	21	.....	0.9
Slightly	13	.....	0.6	.....
Distinctly	8	.....	0.3	.....
Oxidized	.....	615	.....	27.2
Questionably (?)	61	.....	2.7	.....
Slightly (+)	139	.....	6.1	.....
Distinctly (++)	246	.....	10.9	.....
Pronouncedly (+++)	169	.....	7.5	.....
Rancid	.....	146	.....	6.5
Slightly	48	.....	2.1	.....
Distinctly	61	.....	2.7	.....
Pronouncedly	37	.....	1.6	.....
Salty	.....	175	.....	7.7
Slightly	47	.....	2.1	.....
Distinctly	128	.....	5.6	.....
Total	.....	2262	.....	99.9

judgment times (table 2) seem to furnish proof that if the off-flavor is not sensed quickly the chances are that the milk has good to excellent flavor. It should be pointed out that the time reported in table 2 is not taste-reaction time, but flavor judgment time, which includes both the time required to get the taste reaction and the time to identify the sensation of taste. Interestingly, the times found to place judgment on milk having off-flavors embodying the fundamental tastes were in the same order of the reaction times reported in the literature (1, 2), namely, salt, sweet, sour and bitter. The off-flavors in milk having these fundamental tastes were "salty," "high-

TABLE 2

The average time required to "sense" the various flavors in milk

Flavor	Number of samples having specific flavor	Average elapsed time from tasting to passing judgment on the taste reaction (seconds)
Excellent	1222	8.2
Oxidized	615	7.0
Flat	73	6.9
Rancid	146	5.3
High-acid	21	5.2
Cheesy	10	4.9
Salty	175	2.9
Total	2262	7.2

TABLE 3

The weighted-average time to "sense" the various intensities of the oxidized flavor in milk

Intensity of oxidized flavor	Number of samples	Average elapsed time from tasting to passing judgment on the taste reaction (seconds)
Questionably (?)	61	10.1
Slightly (+)	139	9.1
Distinctly (++)	246	7.3
Pronouncedly (+++)	169	3.8
Total	615	7.0

acid" and sometimes "rancid" (bitter and rancid are not always associated), requiring judgment times in that order. Another factor which shortens the judgment time for "salty" milk is the readiness by which saltiness is identified.

The intensity of the flavor has much to do with the time of judgment as any milk judge well knows. Judgment on a pronounced off-flavor often will be made without hesitation whereas considerable time may be required to pass judgment on the same flavor of slight intensity. Data in table 3 on judgment times of milk having various intensities of oxidized flavors bear this out. In fact, the average time to judge milk finally classified as "questionably oxidized" was found to be longer than that required to judge milk classed as "excellent."

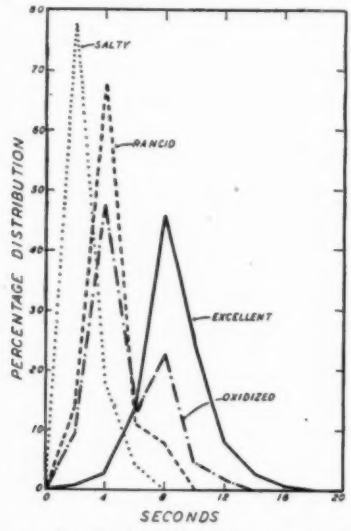

FIG. 1. The percentage distribution of the time required per sample to judge 128 samples of salty, 37 samples of rancid, and 169 samples of oxidized milk having pronouncedly intense off-flavors, and to judge 1222 samples of excellent milk.

In routine judging of milk, some factors seem to obtain which cause a considerable range in the judgment time of the sample. These may include the effects of the preceding sample, time of day, length of tasting period, rapidity of tasting and so on. Although data are not presented for all the off-flavors noted, evidence seems to show (table 2 and fig. 1) that as the average time of judgment increases the range increases also. For example, the range in judgment time for "salty" milk was from 2 to 6 seconds whereas that for "excellent" milk ranged from 2 to 16 seconds.

Percentage distribution studies showed that 78 per cent of 128 distinctly "salty" samples were judged as such in 2 seconds per sample; that 68 per cent of 37 pronounced "rancid" samples were so judged in 4 seconds per sample; that 47 per cent of 169 pronouncedly "oxidized" samples were so judged in 4 seconds per sample and that 46 per cent of 1222 samples of "excellent" milk were classed as such in 8 seconds per sample (fig. 1).

In a study of this kind, the reliability of the judging must necessarily be accepted if the data or their analysis has any merit. That the judgments are not infallible is fully appreciated. However, unpublished data on flavor studies made monthly throughout the year on many samples of milk as well as a study of the reliability of flavor judgments (1) lead one to believe that the flavor judgments reported herein may be accepted with a very high degree of accuracy.

SUMMARY

The average time required to make flavor judgment on 2262 individual samples of milk was noted. This time ranged from a low of 2.9 seconds for "salty" milk to 8.2 seconds for "excellent" milk. The judgment times for "cheesy," "high-acid," "rancid," "flat" and "oxidized" milk were between these extremes and were in the above order. The average judgment time for the 2262 samples was 7.2 seconds per sample. Milk having off-flavors of slight intensity required considerably longer judgment time than did those having pronouncedly intense off-flavors. "Excellent" flavor milk invariably required longer judgment time than did off-flavor milk.

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HEAT COAGULATION OF MILK

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The need for further studies on heat coagulation became apparent during attempts to measure the influence of various electrolytes upon the coagulation temperature of various milks. The data available proved rather limited, and attempts to check certain published results were only partially successful.

A lack of uniform methods, it is felt, largely accounts for the differences obtained by various workers. In the present study, the method adopted was carefully standardized, in an attempt to minimize the error in judgment regarding the point at which coagulation first occurs. Goat's milk as well as cow's milk was used.

REVIEW OF LITERATURE

Hammersten (2) reported that the coagulation temperature of milk varied between 130° and 150° C. Benton (1) found wide variations in the coagulation characteristics of milk from different quarters of the same udder. Sommer and Hart (6), who studied the heat coagulation of milk from individual cows, at 136° C., found that the time of coagulation ranged from 90 seconds to 20 minutes. In their opinion, the main reason for these differences was the relative amounts of calcium and magnesium as compared with citrates and phosphates in milk. Their findings have since been confirmed by various workers.

Rogers, Deysher, and Evans (5) found no correlation between the coagulation temperature of raw mixed herd milk and that of the same milk after evaporation. Subsequent work has substantiated this claim. Holm, Deysher, and Evans (3) determined the relation between the coagulation temperature and the coagulation time (which was 10 to 60 minutes). They found approximately a logarithmic relationship with respect to time. Further, they pointed out that unless calculations were made upon the concentration of milk-solids-not-fat in the fat free portion of the sample, deviations from this relationship might be expected. Later, Webb and Holm (8) studied the effect of various temperatures (80° to 120° C.) upon the coagulation time of several milks containing 9 per cent and 18 per cent milk-solids-not-fat. According to results, as the temperature is increased the coagulation time decreases logarithmically, though the rate of decrease is greater for milks with 18 per cent milk-solids-not-fat than for those with 9 per cent.

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Miller and Sommer (4), studying the coagulation in sealed glass tubes, found that milks were very sensitive to pH changes between pH 6.4 and 6.2 and, to a lesser extent, between pH 5.4 and 5.2. According to them, the coagulation curve was displaced by the presence of added salts as well as by preheating or concentrating. Webb, Bell, Deysher, and Holm (7) found that the difference in stability caused by acid or salts was one of degree; it affected the general heat-stability level rather than the stability interrelationships of milks forewarmed one way or another.

EXPERIMENTAL

Determinations were made for coagulation time of milk samples sealed in glass tubes and heated at various temperatures over the approximate range of 110° to 160° C. Each sample occupied about 40 per cent of the volume of the sealed tube, which was 8 mm. in diameter and 11 to 12 cm. in length. By rocking these tubes slowly during heating in an oil bath, one could easily ascertain the time required for coagulation to occur. Two thermostatically controlled baths were used in the study. They could be regulated to operate at any desired temperature within the range indicated, with a maximum variation of $\pm$ 0.05° C. The tubes containing the samples were mounted on a rocker with clips for 8 tubes. By connecting the arm of the rocker to a motor-driven rotor, one could obtain the desired flow in the tubes. The device was adjusted so that the samples flowed from one end to the other every 20 to 25 seconds, and the tilt was so regulated that agitation was not extreme. Coagulation was judged by observing the point at which the curd particles or clots appeared in the tubes. The procedure was carefully adjusted and maintained throughout the experiments, since, during standardization, the rate of rocking as well as the extent of tilt was found to influence the time of coagulation at a given temperature.

The procedure used somewhat resembles that employed by Miller and Sommer (1940), except that in this study no attempt was made to determine the temperature at which coagulation occurred in a stipulated time. Instead, the time required for coagulation at a given temperature was observed.

Duplicate bath assembles were employed, since preliminary observations showed that satisfactory duplicate results could be obtained with the two units. By heating the same samples simultaneously in two baths at different temperatures, one could obtain the desired data on a given set of samples within 2 days. Properly refrigerating the samples during this period, except while they were being heated, minimized the likelihood of significant changes other than those produced by the heating itself.

The samples used for coagulation studies were analyzed for fat content by the Babcock test, for total solids content by the Mojonnier method, for pH by the Coleman pH meter, and for titratable acidity by titrating 9 ml. of milk plus 9 ml. of water with about N/10 NaOH, and calculating the results as lactic acid.

Samples of milk from individual cows were obtained from the University dairy herd; those of herd milks, from various dairies and from patrons delivering to a market-milk plant. The latter were selected to give predominantly milk from certain breeds or milk from several breeds, according to factors under consideration. A few samples of goat's milk were also included. These were obtained from a dairy milking about 100 goats with three breeds represented.

Considerable variation occurred in the coagulation time of various samples at a given temperature. This finding agrees with results published earlier. Thus at 115° C. the milk from cow 562 coagulated in 151 minutes, whereas that from cow 1076 required 480 minutes. With a set of samples, however, the coagulation time at one temperature was not necessarily an index to the order of coagulation at a different temperature. Sometimes, for instance, with 8 samples at approximately 110° C., the sample that required the longest time to coagulate would be the first to coagulate at about 160° C.; or, vice versa, the first to coagulate at the lower temperature may be the last to coagulate at the higher. Considerable variation, therefore, exists in the nature of the coagulation curves for different samples of milk; and the relative stabilities of samples at one temperature do not indicate what their relative stabilities will be at another.

Table 1 gives coagulation data on one set of samples from individual cows and illustrates the variation just noted. Somewhat similar data for mixed herd milks were obtained; but the results indicate a greater likelihood of obtaining extreme variations with milks from individual cows than from mixed herd milks.

The determinations for fat, total solids, titrable acidity, and pH are given in table 2 for the samples tabulated in table 1.

Unfortunately, coagulation data are not available for individual cows throughout lactation. Data are available, however, for three cows for January, March, and April. Figure 1 clearly indicates that the milk from cow 787 was more heat stable in March and April than in January. With the

TABLE 1

Influence of temperature on coagulation time

Sample No.	Cow No.	Coagulation time at indicated temperatures						
		108.6° C.	115.0° C.	121.5° C.	130.3° C.	140.3° C.	150.7° C.	160.0° C.
		min.	*min.*	*min.*	*min.*	*min.*	*min.*	*min.*
1	562	222	151	85	43.0	17.4	7.2	2.33
2	787	220	192	120	60.0	26.8	11.7	3.17
3	800	284	153	88	40.0	23.3	6.5	2.75
4	805	253	153	83	50.3	22.9	9.3	2.83
5	838	324	191	121	54.7	23.8	9.3	2.25
6	1074	275	192	94	51.1	11.8	4.6	2.00
7	1075	380	206	122	49.8	20.0	7.2	2.33
8	1076	720	480	244	107.0	35.7	3.2	1.50

TABLE 2

Composition, titratable acidity, and pH values on samples used in table 1

Sample No.	Cow No.	Fat	T.S.	Titratable acidity	pH	
		%	%	%	*4–3–45*	*4–5–45*
1	562	4.8	14.68	0.21	6.50	6.48
2	787	5.0	16.65	0.21	6.60	6.60
3	800	5.8	15.75	0.23	6.45	6.42
4	805	6.9	17.50	0.24	6.55	6.54
5	838	4.6	14.15	0.23	6.50	6.50
6	1074	4.0	12.77	0.20	6.55	6.53
7	1075	3.8	12.20	0.19	6.50	6.45
8	1076	3.5	11.90	0.17	6.60	6.57

other two animals, the differences are less great; in fact, their milks are slightly less stable in April than in January, and most stable in March. Differences in stage of lactation or, possibly, differences in feeding may account for part of these variations; but individual cow differences undoubtedly also play a part. This latter point is illustrated in figure 2, giving data for cows 838 and 1076.

Figure 3 shows results with one set of mixed herd samples. If the logarithm of the coagulation time for these samples is plotted against temperature, significant variations from a straight-line relationship occur. Such a plot has been made in figure 4 for one set of samples from individual cows. The data from three such series (7 or 8 samples per series) were examined along with one series of mixed herd milk to see whether they could be made to fit a straight line when the logarithm of coagulation time is plotted against coagulation temperature.

For each curve, representing the experimental data for one milk sample, a straight line was drawn through two points established by averaging the experimental values for each half of the curve. Since the curves did not all

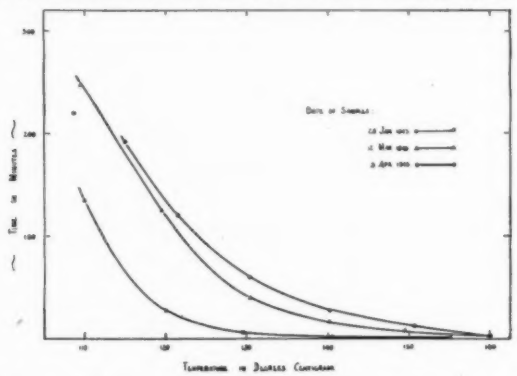

FIG. 1. Variations in heat stability of milk from cow 787.

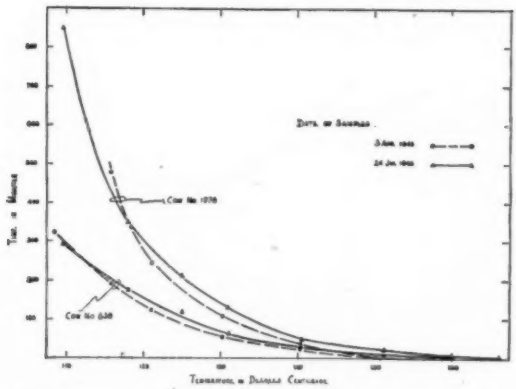

FIG. 2. Differences in heat stability of milk from cows 838 and 1076.

include the same number of established points, the averages used were data from three to five experimental points, for that part of the curve under consideration. The center part of the curve was weighted somewhat by overlapping one or two points in arriving at the averages noted. For each sample, a curve was drawn showing the deviations from this straight line. These differences were then averaged for each series of samples, and figure 5 gives the deviations. The curve for April 2 in figure 5 represents the set of samples shown in figure 4.

In all the series, the variations are consistent. Even if the straight lines considered were drawn by inspection, the deviations would give curves of the type indicated. In other words, the line that best fits the data deviates significantly from a straight line. Although not presented, the fourth series shows the same type of curve.

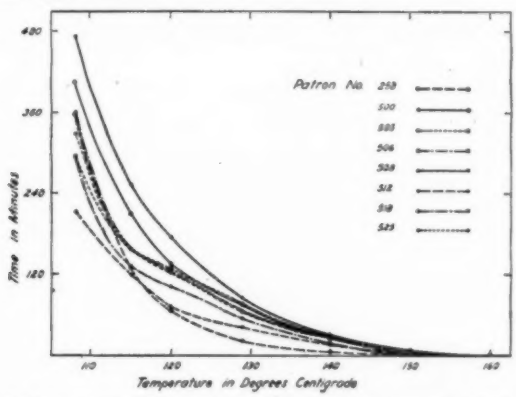

FIG. 3. Relation of coagulation time to coagulation temperature for 8 samples of of mixed herd milk.

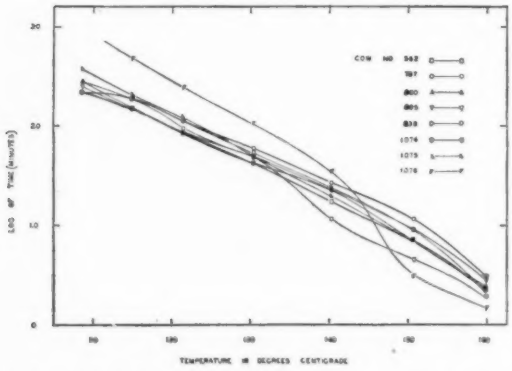

FIG. 4. Relation of logarithm of coagulation time to coagulation temperature for 1 set of samples from individual cows.

Goat's milk shows a greater deviation in this regard than cow's milk. When data for such milk are plotted, as in figure 6, with logarithm of coagulation time and coagulation temperature as coordinates, then deviations from a straight line are so apparent that no further plotting seems necessary. Most of the samples, however, show a fairly straight-line relationship if only parts of the curves are selected for consideration.

In comparing the data in table 4 with those in table 1, one sees that the coagulation times for goat's milk at 134° C. are about the same as they are for cow's milk at 155 to 160° C. At about 110° C., on the other hand, goat's milk coagulates no faster than cow's milk.

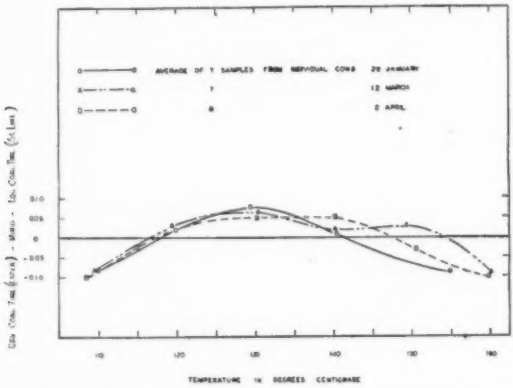

FIG. 5. Deviations from a straight line of "log time-temperature" relationship for 3 sets of samples from individual cows.

TABLE 3

Data on goat milk samples used for coagulation tests

Sample No.	Goat name	Bacteria per ml.	Titratable acidity	pH	Fat	Total solids	M–S–N–F
			%		%	%	%
1	Composite— 10-gal. can	5150	0.13	6.54	3.7	11.88	8.18
2	Geraldine	325	0.15	6.54	4.4	13.15	8.75
3	Sophie	250	0.13	6.60	4.2	12.52	8.32
4	Zella	105	0.18	6.31*	3.0	11.09	8.09
5	Victoranne	1190	0.12	6.60	3.8	12.48	8.68
6	Eureka	150	0.11	6.69	3.9	11.68	7.78
7	Rosebud†	695	0.12	6.67	3.4	11.44	8.04
8	Paloma	90	0.12	6.61	3.2	11.10	7.90

* No explanation is available to account for the low pH of this sample.

† Rosebud freshened June 5, 1943; and she was milked twice daily from then until this sample was collected on July 2, 1945.

DISCUSSION

The complexity of the phenomenon of heat coagulation of milk is re-emphasized by the data presented. Lack of agreement among various workers is probably due—in part, at least—to differences in methods of determining coagulation. All agree, however, that there are marked variations in the heat stability of different milks.

Because of variations in the characteristics of the curd or coagulum formed when milk is heated, it is sometimes difficult to ascertain just when coagulation occurs. This is true when a very soft curd is produced, since only slight agitation may be required to break up the curd. If, on the other hand, a firm curd is produced, the coagulation point is easily ascertained. In this report differences in the type of clot or coagulum are not noted, although they were regularly observed throughout this study. The character of some clots may be more important than the time required to produce them. Workers should recognize that marked differences do occur in this regard.

TABLE 4

Influence of temperature on coagulation time for goat milk

Sample No.	Goat name	Time of coagulation at indicated bath temperature					
		109.5° C.	115.2° C.	120.5° C.	127.3° C.	134.0° C.	140.5° C.
		min.	*min.*	*min.*	*min.*	*min.*	*min.*
1	Composite— 10-gal. can	525	335	202	94	1.5	0.6
2	Geraldine	424	300	188	113	2.0	0.4
3	Sophie	558	363	249	140	3.5	0.6
4	Zella	848	450	61	5.5	0.5	0.5
5	Victoranne	548	346	249	130	4.5	0.9
6	Eureka	466	339	227	138	1.0	0.8
7	Rosebud	537	349	231	130	7.5	1.8
8	Paloma	820	460	32	5	1.2	0.4

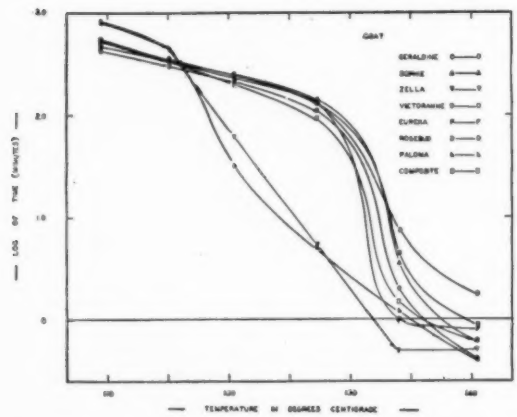

FIG. 6. Relation of logarithm of coagulation time to coagulation temperature for 8 samples of goat's milk.

Variations in heat stability are shown for milk from individual cows and mixed herd milk at the same season of the year, as well as differences in heat stability of milk from the same cows at different seasons. The data also show that for a series of samples tested simultaneously, the relative stabilities to heat are apt to vary according to the temperatures of observation. That is, the order of coagulation may be different at one temperature than at another.

According to Holm, Deysher, and Evans (3), when the concentration of milk-solids-not-fat in the fat-free portion is considered, there is a logarithmic relationship between coagulation time and coagulation temperature. In the present experiments, a consideration of concentration of milk-solids-not-fat in milk as it is normally secreted did not change the relationship already shown—namely, that there is a significant deviation from a straight line when a sufficient temperature range is considered.

There are interesting differences in the heat coagulation characteristics of milk from cows and goats. What constituents are responsible is not clear; but, since slight changes in certain components of milk may cause significant changes in heat stability, these differences are in keeping with expectations.

SUMMARY AND CONCLUSIONS

1. A method of determining coagulation times at various temperatures is described, and results obtained over the approximate temperature range of 110° to 160° C. are reported for both cow's and goat's milk.

2. Marked differences occurred in the nature of the coagulum produced as a result of heating various samples of milk.

3. Considerable variation was also found between the samples of cow's milk so far as coagulation time at a given temperature was concerned. Somewhat similar differences were observed between samples of goat's milk.

4. There seemed to be a characteristic difference between cow's and goat's milk, since coagulation times for goat's milk at 135° C. are about the same as for cow's milk at 155° to 160° C. Other differences are also pointed out.

5. Although, over a limited temperature range, most samples show a fairly straight-line relationship between coagulation temperature and logarithm of coagulation time, there was considerable variation from this relationship when the approximated temperature range of 110° to 160° C. was considered.

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MERCURIMETRIC METHOD FOR SALT DETERMINATION IN BUTTER AND NEW CHEESE

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Accurate determinations of the salt content of dairy products are important because of the effect which salt has upon the flavor and quality of these products. The chlorine content of fresh milk is often used as a basis for judging the quality and detecting physiological abnormalities of milk at the intake in market milk plants. The Volhard and Kohman methods are generally used for making chloride determinations of dairy products. Several investigators have recommended making modifications of these methods on the basis that it is difficult to detect the point of neutralization in the titration technique used. This allows considerable latitude for interpretation of results and it is not unusual for the results obtained from different laboratories to vary widely.

REVIEW OF LITERATURE

A complete review of the literature concerning the determination of chlorine in milk is given by Sanders (5). Sanders (5) proposed a modification of the Volhard method for determining chlorine in milk and describes the sources of error and methods of improvement in other methods, as well as conditions necessary for accurate Volhard titrations.

Skelton and Bryant (7) suggested the use of dichlorofluorescein as an indicator, in order to secure a more distinct and sudden end point in the titration procedure in either the official or factory method for determination of salt in butter.

Marquardt (3) has pointed out the need for a simple usable procedure for rapidly determining the salt percentage in freshly made commercial cheeses of all varieties and suggested a procedure based upon the Sammis method (4). He shows that it is possible to obtain reliable results by titrating directly aliquots of solutions prepared from freshly made cheeses less than five days old. The results secured on several varieties of fresh cheese compared favorably with those obtained by the modified Volhard method (8), approved by the American Dairy Science Association. He also showed that potassium chromate and dichlorofluorescein gave comparable results when used as indicators for the direct titrations with silver nitrate, but it was not possible to obtain accurate values with cured cheese by direct titration because water-soluble proteins rendered this procedure unsuitable for certain cheese over five days old.

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A mercurimetric titration method, using s-diphenylcarbazone as an indicator, has been suggested by Schales and Schales (6) for determining chlorine in biological fluids. It is stated that this method has been found to be free from errors that are frequently encountered in other chloride determination procedures. The chloride combines with mercuric ions, according to the equation, 2 Cl′–Hg″, without forming a precipitate. Mercuric chloride is very slightly disassociated, and the end point of the titration is therefore easily recognized by the appearance of mercuric ions in solution.

The purpose of this investigation was to establish the value of a mercurimetric method, using the s-diphenylcarbazone indicator as a test for chlorides and salt in milk and milk products.

PROCEDURE

A study was made to determine if the mercurimetric method, using s-diphenylcarbazone as an indicator, could be modified for use as a laboratory or plant method in determining the chloride content of fresh milk. Special attention was given to the various factors, such as concentration of solutions, amount and method of treating sample and amount of indicator, upon the results secured.

A further study was made to determine if the mercurimetric method could be modified for use as a laboratory or plant method in determining the salt content of butter, American cheese and soft cheese. A number of commercial samples of the various products were analyzed for salt content by the mercurimetric method. The results secured were compared with those secured by commonly used methods and the accuracy of the method was checked by recovery tests on samples of the product to which a known amount of salt had been added.

Lastly, an attempt was made to establish the value of the mercurimetric method for miscellaneous uses in the dairy industry.

RESULTS

No satisfactory method was found for using the mercurimetric method in determining the chloride content of fresh milk. Various methods of preparing the sample were employed including making different dilutions of the sample, using different amounts of the sample and also ashing of the sample. Varying amounts of indicator ranging from 0.1 ml. to 1 ml. for a 10-ml. sample were used and solutions of different concentration were used but a definite color change at the neutralization point was not secured.

The procedures which gave satisfactory results for estimating the salt content of butter, new cheese and cottage cheese by the mercurimetric method are as follows.

Reagents and Procedures

Mercuric nitrate solution—0.1711 N. Dissolve 29.31 g. of mercuric nitrate C.P. in a few hundred ml. of water with the addition of 40 ml. of 2 N nitric acid and make the solution to one liter volume with distilled water. The correct amount of nitric acid must be used in preparing the standard mercuric nitrate solution since if more or less acid is used the end point in the titration technic will not be as sharp.

Nitric acid—2 N. Dilute approximately 127 ml. of concentrated nitric acid (about 16 N) to one liter volume with distilled water. Use to prepare the mercuric nitrate solution.

s-Diphenylcarbazone indicator solution. Dissolve 100 mg. of s-diphenylcarbazone (Eastman 4459) in 100 ml. of neutral ethyl alcohol and store in a dark place preferably in a refrigerator. The correct amount of indicator must be used and best results are secured if the indicator is stored not longer than one month.

Standard sodium chloride—0.1 N. Dissolve 5.845 g. of sodium chloride C.P., dried at 120° C., in water and make to one liter volume. Use the standard sodium chloride to standardize each new solution of mercuric nitrate. Standardize each new solution of mercuric nitrate by measuring 25 ml. of the standard sodium chloride solution into a 125-ml. Erlenmeyer flask. Add 0.6 ml. of indicator solution and titrate slowly with the mercuric nitrate solution. The clear solution turns a pale violet at the end point and an intense violet-blue color on the addition of one drop of mercuric nitrate in excess.

In protein-free solutions the color change is as described above. In protein-containing solutions the color of the turbid liquid is salmon red after the addition of the indicator, but changes as the titration is started, to violet. As the titration proceeds the solution becomes clear and pale yellow to colorless and at the end point there is a sharp change to pale violet.

Estimation of the Salt Content of Butter

Weigh a 10-g. sample of butter into a counterpoised beaker. Secure 250 ml. of washings from the sample as directed in the Official Method (2) for determining salt in butter. Or for plant laboratory procedure, after the moisture and fat determinations have been made by the Kohman method, rinse the dry residue into a 250-ml. volumetric flask with three separate 30-ml. portions of hot distilled water. Cool the rinsings; dilute to the 250-ml. graduation mark on the flask and mix thoroughly.

Pipette a 25-ml. portion of the solution into a 125-ml. Erlenmeyer flask. Add 0.6 ml. of *s*-diphenylcarbazone indicator. Titrate slowly with standard mercuric nitrate solution using a burette graduated in 0.1-ml. divisions. Single drops should be approximately 0.05 milliliter. The clear and colorless solution turns a pale violet color on the addition of one drop of mer-

curic nitrate at the end point and an intense violet-blue color on the addition of one drop of mercuric nitrate in excess. The ml. of 0.1711 N mercuric nitrate used in the titration equal the percentage salt in the sample.

Estimation of the Salt Content of New Cheese and Cottage Cheese

Grind the sample of new cheese or cottage cheese finely to reduce to a homogeneous consistency. Weigh 10 grams of the prepared sample into a 400-ml. beaker. Add 250 ml. of distilled water and heat to 150–160° F. Mix thoroughly and allow to cool to room temperature. Remove a 25-ml. portion of the clear solution and place in a 125-ml. Erlenmeyer flask. Titrate with mercuric nitrate as described for butter. The ml. of 0.1711 N mercuric nitrate used equal the percentage of salt in the sample.

Recovery Tests

Tests were made using the procedure suggested above to determine the correct color change to use as the end point in the mercurimetric method. Samples of butter of exactly known salt contents were examined by the mercurimetric method. The readings were taken upon the occurrence of the pale violet color just before one more drop of mercuric nitrate produced the intense violet-blue color. The reading was also taken upon the occurrence of the intense violet-blue color which represented one drop of mercuric nitrate in excess. Table 1 shows the results obtained.

TABLE 1

The relation of color change in the mercurimetric procedure to the exact salt content of butter

Sample	Known amount of NaCl	Mercurimetric method	
		Pale violet color NaCl	Intense violet-blue color NaCl
	percentage	*percentage*	*percentage*
1	0.994	0.99	1.03
2	1.987	1.98	2.02
3	2.981	2.95	3.00
4	3.974	3.98	4.04
5	5.026	5.00	5.05
Ave. variation from exact amount	.....	−0.015	+0.036

The results given in table 1 show that the most accurate results are secured by taking the reading upon the occurrence of the pale violet color just before an extra drop produced an intense violet-blue color. The pronounced violet-blue color may be used as an end point with only slightly higher results.

Table 2 shows the agreement obtained in comparing the mercurimetric method and the silver nitrate-potassium chromate method in recovery tests

on samples of butter and cheese containing known added amounts of salt. The silver nitrate-potassium chromate method for the butter examination was the modified Kohman method approved by the American Butter Institute (1), and the method used for the determination of the salt content of cheese was that suggested by Marquardt (3).

Table 2 shows that the results secured on recovery tests by the mercurimetric method compared favorably with those secured by the silver nitrate–potassium chromate method.

The salt content of a number of samples of butter and new cheese was determined by the mercurimetric and the silver nitrate–potassium chromate methods. The butters varied in quality and ranged in salt content from 1.5 to 3.0 per cent. The cheese varied from 0.5 to 4.5 per cent in salt

TABLE 2

Recovery tests on butter and cheese of known salt content by the mercurimetric and the silver nitrate-potassium chromate methods

Sample	Known added amount of NaCl	Mercurimetric method NaCl	Silver nitrate-potassium chromate method NaCl
	percentage	*percentage*	*percentage*
Butter			
1	0.994	0.99	1.02
2	1.987	1.98	2.04
3	2.981	2.95	3.06
4	3.974	3.98	3.99
5	5.026	5.00	5.08
Cheese			
1	0.986	0.97	1.00
2	1.972	1.97	2.00
3	3.016	3.00	3.05
4	4.002	4.01	4.02
5	4.988	4.95	5.02

content and were composed mostly of new cheddar and cottage cheese, although a few other varieties were included.

The results secured by the two methods are shown in table 3 and indicate that the mercurimetric method gives somewhat lower results than the silver nitrate–potassium chromate method.

Observations indicated that in the cheese samples examined, the water-soluble protein was less likely to cause inaccurate results when the mercurimetric method was used. Lower and more accurate results were secured for both the butter and the cheese samples when the mercurimetric method was used. In cheese where considerable water-soluble protein is present, the color change with the mercurimetric method is that as described for protein-containing solutions.

Miscellaneous Application

An attempt made to establish a method for the use of the mercurimetric

TABLE 3

Salt determinations of butter and cheese by the mercurimetric and the silver nitrate-potassium chromate methods

Kind of sample	Number of samples	Mercurimetric method NaCl	Silver nitrate-potassium chromate method NaCl
		Ave. percentage	*Ave. percentage*
Butter	25	2.77	2.81
Cheese	17	1.34	1.44

method in determining the chlorine content of commercial preparations and chlorine rinsing solutions failed to produce a satisfactory procedure.

A procedure was found which gave satisfactory results for use in detecting the presence of mercuric chloride in preserved samples of milk. The sample of milk was thoroughly mixed. One ml. of the milk sample was removed for examination. Four drops of the *s*-diphenylcarbazone indicator, prepared as previously described, were added to the 1-ml. portion of the sample removed. The occurrence of a violet-blue color indicated the presence of mercuric chloride. A definite color change was produced by as little as one part of mercuric chloride in 100,000 parts of milk.

DISCUSSION AND CONCLUSIONS

The mercurimetric method for salt determination as reported in this paper is somewhat more delicate, gives accurate results and has the advantage of giving a sharp and permanent end-point in comparison to titrating with standard silver nitrate using potassium chromate as an indicator. An intense violet-blue color occurs upon the addition of one drop of mercuric nitrate in excess. Mercuric nitrate is considerably cheaper than silver nitrate, but the *s*-diphenylcarbazone is not as readily available as potassium chromate as an indicator.

The results indicate that the mercurimetric titration method can be successfully adapted for use as a salt test for butter and new cheese and the *s*-diphenylcarbazone indicator can be used in a procedure for detecting the presence of mercuric chloride in milk. The mercurimetric method does not seem to be adaptable to procedures requiring digestion of the sample, and no satisfactory procedure was found for using the mercurimetric method as a direct titration procedure for determining the chlorine content of milk, nor for determining the chlorine content of chlorine sterilizers used in the dairy industry.

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CRYOPHILIC ORGANISMS IN WATER AND BUTTER

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INTRODUCTION

Any organism capable of growth at refrigerator temperatures may be important in the keeping quality of dairy products. It is recognized that many organisms, which exhibit optimum growth at room temperatures or above, may grow in the vicinity of 5° to 10° C., but the most important are those true cryophiles which have their optimum growth in that range.

In spite of the extensive use of low temperatures for storing dairy products, analyses in the bacteriology laboratory and keeping quality tests most frequently employ incubation temperatures of 20° to 37° C. While certain time-saving advantages are offered by the use of higher temperatures, it is well to recognize that the use of incubation temperatures more closely approaching storage conditions are more apt to give results which represent changes occurring under commercial conditions. It is admitted that from the public health standpoint, 37° C. incubation may be desirable, but for purely commercial reasons, it is stressed that the use of higher incubation temperatures may give a false picture of what happens under storage conditions.

REVIEW OF LITERATURE

The available literature reveals the fact that a number of defects of dairy products may be attributed to the action of cryophilic organisms.

Several investigators (6, 14, 22, 30, 31) have attributed ropiness in milk to organisms showing active growth in the neighborhood of 10° C. In a number of cases the organisms at fault were traced to water supplies.

Pigment production at low temperatures may take place in milk and cream on rare occasions, but commercially it is more important so far as butter is concerned. Several papers (19, 26, 43, 44) have reported organisms isolated from butter which were capable of rapid pigment production at low temperatures. *Pseudomonas nigrafaciens* was concluded to be the causative organism in some of the cases cited.

Cryophiles, both obligate and facultative, may be responsible for the failure of fluid dairy products to meet commercial and public health bacterial standards even though the products in question are handled and stored according to approved procedures (17, 27, 28, 42). Cryophilic bacteria

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may cause milk samples to show unsatisfactory methylene blue tests. High counts have been caused by the vigorous growth of organisms after the cream has been pasteurized, bottled, and stored at refrigerator temperatures. Cream shipped from Midwestern creameries to Eastern markets has been threatened with rejection because of high bacterial counts. The increase in count has taken place during shipment in refrigerated cars. A number of cryophilic organisms have shown phosphatase activity, and consequently the phosphatase test should be used with discretion on butter which has been subjected to a holding period which would allow considerable growth.

Organisms growing at low temperatures may be responsible for off-flavors and odors in all dairy products, but chiefly butter, because of the length of time it may be stored at temperatures just above freezing. The spoilage of milk and cream standing at low temperatures is characterized principally by proteolysis and the development of a bitter flavor (16, 36). Butterfat likewise may be attacked at refrigerator temperatures and cream spoilage is common (2, 3, 24).

Rancidity in butter may be caused by the action of microorganisms growing at low temperatures (13, 22, 39). Active growth in the region of 5° C. has been accompanied by the development of rancidity in artificially seeded butter.

It has been shown (18) that cheesy flavors develop quickly at low storage temperatures, and that extensive bacterial growth takes place in the vicinity of 5 to 10° C. The use of higher storage temperatures (21° C.) resulted in defects not typically cheesy and only slightly resembling those developed at the lower temperatures.

Surface taint is another defect of butter appearing at low temperatures (10, 12, 13, 15, 21). Organisms producing such defects have been traced to defective water supplies in many instances (10, 11, 15, 18, 21, 25, 32, 34, 35, 38, 41). These organisms, in a majority of cases, apparently belong to the genera *Pseudomonas* and *Achromobacter*. Several workers (20, 23, 29, 31) have stressed the importance of types, rather than numbers, present in butter since the temperature of holding influences the growth of microorganisms in the product in question.

The use of low incubation temperatures for analyses of creamery water supplies is advocated in several papers (8, 23, 45), and it has been shown that low temperature incubation gives in some cases vastly different results than incubation at high temperatures.

EXPERIMENTAL PROCEDURE

Water samples for the analyses were obtained from Minnesota and Wisconsin creameries which had been experiencing trouble with butter which kept poorly. Butter samples were obtained from a number of sources. All showed a pronounced defect which either appeared in a print

of butter under commercial conditions or which resulted when various butters were subjected to a routine keeping-quality test. Only samples which developed a type of defect ostensibly the result of bacteriological action were selected.

The basal medium from which the various other media were prepared for making differential counts of lipolytic and caseolytic types of organisms was essentially the "Standard Methods" agar (1) from which the skim milk was omitted. For determining lipolytic types, nile blue sulfate-butterfat was used and prepared according to Knaysi's method as cited by Stark and Scheib (40). Caseolytic types were counted on a skim milk agar prepared by adding, at the time of plating, 5 ml. of sterile skim milk to 100 ml. of the basal medium, melted and cooled to 45° C.

Water and butter samples were plated in suitable dilutions for the determination of total, lipolytic, and caseolytic counts. Duplicate plates of each dilution were incubated at 37° C. for two days, 20° C. for five days, and 8° C. for seven days, respectively. In addition, the water samples were inoculated into brilliant green-lactose-bile broth as a presumptive test for the presence of coliform organisms, using 1.0 and 0.1 ml. inocula, and with incubation for two days at 37° C.

Well-isolated colonies showing typical lipolytic and caseolytic reactions on the plates incubated at 8° C. were picked from the plates and inoculated into litmus milk. The litmus milk tubes were allowed to incubate for five days at 8° C. The cultures were then streaked on plates of the basal medium. A discrete colony, typical of the culture on the plate, was again picked for seeding into litmus milk and the process repeated in order to get a pure culture.

Methods and media used for the identification of the cultures were mostly those suggested in the "Manual of Methods for Pure Culture Study of Bacteria" (37). Differentiations were made on the basis of morphological and biochemical characteristics. In addition to the above, the growth temperature range and tolerance, pasteurization survival, and the presence of an oxidase enzyme were also determined. Growth temperature range and tolerance were determined by inoculating slants of the "Standard Methods" agar (1) and incubating at 8°, 20°, 37°, and 50° C. Observations on the presence and relative amounts of growth were made at the end of two, five, and seven days incubation.

Pasteurization survival was determined after inoculating two-day-old pure cultures into skim milk, holding at a temperature of 65.5° C. (150° F.) in a constant temperature bath for thirty minutes, cooling, and then preparing streak plates to determine the presence of any viable organisms. Oxidase-producing organisms were detected by the use of p-aminodimethylanaline monohydrochloride, according to the method suggested by Castell and Garrard (7).

Bergey's *Manual of Determinative Bacteriology* (5) was the basis for identification.

All of the cultures identified were inoculated into sterile cream to determine the type of defects they were able to cause at 8° and 20° C. Samples of cream incubated at the above temperatures were examined at regular intervals for type and intensity of defect produced. Further work was attempted using a sample of decomposed cream, consisting of a mixture of these incubated samples. The cream was distilled under vacuum, which resulted in a boiling point of 43° to 47° C. The distillate from the decomposed cream was compared with that from a sterile control sample held under the same conditions. Qualitative tests for the presence of sulfides, mercaptans, and sulfates, as well as a nitro-prusside test, were made on the distillate.

Five pure cultures selected on the basis of the type and intensity of proteolytic defect produced were inoculated into larger amounts of cream and skim milk. The samples were judged for type and intensity of defect, and the acidity and a formol titration as proposed by Clark and associates (9) were run on each culture. The remainder of the sample was then vacuum distilled as mentioned previously. Tests were made for the volatile sulfides and mercaptans which did not condense in the distillate. The distillate was compared with the original cream for the presence of odors and was examined qualitatively as previously stated. In addition, the distillate was examined quantitatively for mercaptans by a modification of the method of Bell and Agruss (4). A Coleman glass electrode pH electrometer, model 3D, was used for pH readings and in titration procedures.

RESULTS

I. *Bacterial counts on water and butter samples.* It is a well-known fact that the temperature of incubation influences the number of colonies appearing on a plate. The data are presented to compare the effects of the three incubation temperatures used on the demonstrable flora present in the samples examined. As would be expected, the water samples showed considerable variation both in total and differential counts.

Table 1 presents the results obtained on the water samples. A number of the waters plated had counts at all temperatures which were so low as to be quite insignificant. However, a number of the waters, particularly the untreated samples, showed considerable counts. In a majority of the samples plated, 37° C. incubation gave lower counts than incubation at 20° C. In general, it is obvious that 37° C. incubation may not reveal a count representative of the sample in question. This statement is supported by the observation that in no instance did 37° C. incubation give a maximum count. Caseolytic and lipolytic counts obtained at 37° C. showed the same relationship as the total counts. Also, it is to be noted that only in a few

TABLE 1

Bacterial counts of water samples

Sample	Incubation temperature	Total count	Proteolytic count	Lipolytic count
	°C.	*per ml.*	*per ml.*	*per ml.*
1	37	178	61	1
	20	410	76	10
	8	61	10	10
2	37	10	1	1
	20	16	10	1
	8	10	1	1
3	37	11	10	1
	20	36	10	10
	8	13	1	1
4	37	11	10	1
	20	14	10	1
	8	10	1	1
5	37	17	10	1
	20	76	10	10
	8	10	1	1
6	37	10	1	1
	20	28	10	1
	8	x	x	x
7	37	45	14	1
	20	76	22	10
	8	x	x	x
8	37	10	1	1
	20	164	35	18
	8	x	x	x
9	37	10	1	1
	20	20	10	1
	8	x	x	x
10	37	2,180	370	37
	20	38,000	13,500	610
	8	16,700	4,000	480
11	37	62	1	1
	20	3,270	33	250
	8	3,450	37	1,120
12	37	162	11	1
	20	32,600	230	14,100
	8	TNTC	38	680
13	37	1	1	1
	20	20	1	10
	8	10	1	1
14	37	1	1	1
	20	10	1	10
	8	1	1	1
15	37	280	40	23
	20	830	110	83
	8	322	90	36
16	37	1	1	1
	20	38	10	1
	8	10	1	1

(x) Plates discarded because of SO_2 leak in incubator. TNTC—too numerous to count in 1: 100 dilution.

instances were considerable caseolytic and lipolytic counts demonstrated at 37° C.

The presumptive tests for the presence of coliform organisms using brilliant green-lactose-bile broth were negative in all cases.

Total counts obtained at 20° C. were, in general, the maximum counts obtained for the samples plated. However, there were several exceptions. It should be emphasized that in four samples the total count at 20° C. was from ten to two hundred times more than the count obtained on the same sample at 37° C. A similar general relationship could be found for caseolytic and lipolytic counts at 20° C. In a majority of cases there were larger numbers of these organisms demonstrated at 20° C.

Incubation at 8° C. produced some variable results. So far as the data are concerned, there were fewer samples with complete data at 8° C. due to an accident. However, with the twelve samples on which considerable data were obtained, it may be observed that in only one case did the count at 37° C. exceed the total count at 8° C. Several samples showed counts at 8° C. greatly exceeding those obtained at 37° C. In fact, the counts at 8° C. in two cases were maximum for the temperatures used, and in one case, were significantly greater than those obtained at 20° C.

The differential counts at 8° C. did not follow the same relationship as those at the other temperatures used. In comparing the percentages of total numbers which were caseolytic and lipolytic at a given temperature, it may be seen that the temperature of incubation affected the lipolytic and caseolytic types more than the total count. In a majority of samples, the percentage of caseolytic and lipolytic organisms was greater at 20° C. and 8° C. than at 37° C.

The results obtained indicate that the various incubation temperatures exert a great influence on the number of organisms demonstrated in some samples. Even on the basis of the small number of samples plated, it appears that there is a trend for higher counts to appear at temperatures other than 37° C. This holds both for high and low count samples. Also, the flora measured and the balance of types is entirely different at the various temperatures. While the results are not complete so far as the 8° C. incubation is concerned, we may see that in relation to the maximum counts obtained, incubation at 8° C. generally revealed a considerable percentage of the organisms present, and at times might develop the maximum numbers capable of being counted.

II. *Bacterial counts on butter samples.* Data on the butter samples are presented in table 2. Again, the data are not complete for all samples because of the accidental loss of plates in five cases. The results obtained show that the first twelve samples gave very high counts when plates were incubated at 20° C. Likewise, there were considerable numbers of lipolytic and caseolytic organisms present. It may be observed also that there was no

uniformity in the ratios of the lipolytic and/or the caseolytic to the total counts in the samples studied. As with the water samples, the flora of the butter samples depended on the individuality of each sample studied.

The data also show that there may be considerable numbers of organisms in butter which are capable of growing at 8° C. However, the same rela-

TABLE 2

Bacterial counts of butter samples

Sample	Incubation temperature	Total count	Proteolytic count	Lipolytic count
	°C.	per ml.	per ml.	per ml.
B1	20	10,000,000	est. 2,000,000	1,280,000
	8	x	x	x
B2	20	5,960,000	40,000	59,000
	8	x	x	x
B3	20	4,890,000	380,000	119,000
	8	x	x	x
B4	20	7,000,000	est. 2,000,000	320,000
	8	x	x	x
B5	20	4,860,000	430,000	22,000
	8	x	x	x
B6	20	2,170,000	40,000	6,000
	8	6,000	1,000	1,000
B7	20	2,670,000	9,000	83,000
	8	98,000	1,000	1,000
B8	20	2,530,000	270,000	70,000
	8	420,000	1,000	1,000
B9	20	60,000,000	TNTC	90,000
	8	1,310,000	1,000	1,000
B10	20	10,800,000	1,600,000	470,000
	8	1,950,000	1,000	1,000
B11	20	4,800,000	900,000	14,000
	8	630,000	1,000	1,000
B12	20	1,470,000	310,000	1,000
	8	88,000	1,000	1,000
B13	20	24,000	5,000	1,000
	8	1,000	1,000	1,000
B14	20	51,000	4,000	3,000
	8	1,000	1,000	1,000
B15	20	23,000	4,000	2,000
	8	3,000	1,000	1,000
B16	20	38,000	4,000	1,000
	8	1,000	1,000	1,000
B17	20	43,000	3,000	1,000
	8	8,000	1,000	1,000
B18	20	27,000	10,000	1,000
	8	5,000	1,000	1,000
B19	20	36,000	3,000	1,000
	8	1,000	1,000	1,000
B20	20	43,000	2,000	2,000
	8	1,000	1,000	1,000

(x) Plates discarded because of SO_2 leak in incubator. TNTC—too numerous to count in 1 : 1,000,000 dilution.

tionships as are found with the water samples do not obtain. Nevertheless, the presence of cryophilic organisms in the butter samples has been conclusively demonstrated.

III. *Identification of the cultures isolated.* Forty-one cultures were isolated and identified as to genus. The results indicate that the isolated organisms were quite closely grouped, and the majority seemed to fall into one genus. Twenty-eight of the cultures were classified as belonging to the genus *Pseudomonas*, the majority of these cultures being able to produce a green fluorescence in culture media. Five cultures were placed in the genus *Flavobacterium* because of their ability to produce yellow pigment. Six cultures of gram-negative rods, showing little or no activity on culture media, were placed in the genus *Alcaligenes*. One culture was placed in the genus *Achromobacter*. One yeast culture was isolated and cultural characteristics determined, but no attempt was made to identify it.

The results of pasteurization survival studies have commercial importance since heat treatment of butter wash-water supplies has been advocated by a number of authors. Six of the forty-one cultures were able to survive exposure to 150° F. for 30 minutes. The surviving organisms showed considerable caseolytic activity.

A number of the cultures studied were able to produce an oxidase reaction of marked intensity. Castell and Garrard (7) have observed that most dairy products, showing defects caused by bacteria, have a flora extremely high in this type and that culpable water supplies likewise possess such organisms. The close relationship between these cultures and their ability to produce defects is emphasized by the results obtained in the incubation studies using sterile cream as a substrate.

IV. *Incubation studies using cream and skim milk.* All of the identified pure cultures were inoculated into sterile cream, followed by incubation both at 8° C. and 20° C. for the purpose of determining the type of defect produced from milk constituents. Repeated studies with these cultures indicated that odor production in cream both in type and intensity was quite constant under given conditions. The results showed that the temperature of incubation influenced the type of defect developed. The defects developed at 8° C. could be more specifically described and more closely resembled the typical butter defects than those at 20° C. The cream incubated at higher temperatures, in the majority of cases, became extremely putrid in a short time. The length of incubation period likewise played a part in the development of typical defects in that changes were constantly occurring within the culture as to the type and concentration of substances detected organoleptically.

A mixed sample of the worst cream cultures was compared with a sterile cream control in attempting to develop a procedure whereby some of the volatile sulfur compounds might be measured both qualitatively and quan-

titatively. The distillates from the deteriorated cream were subjected to a number of qualitative tests for sulfur-containing compounds. The results of this work are presented in table 3. The distillate from the decomposed cream was without doubt different from that of the cream control. The data showed a stronger nitroprusside test, a stronger test for sulfides and sulfates (on oxidation) in the distillate from the decomposed cream. The distillate in the sterile control gave slight reactions to the nitroprusside test and the presence of sulfides and sulfates. This is to be expected because of the heat treatment of the cream prior to the incubation test.

The inoculation of five pure cultures into sterile skim milk and cream produced some interesting results. The cream and skim milk were compared to determine if the defect produced would be affected by the composition of the substrate used. The acidity and formol titration were run as an index of the extent of decomposition, and an attempt was made to correlate these results with the type and intensity of defect as judged or-

TABLE 3

Effect of bacteria on cream as measured by qualitative tests on the distillate

	Control	Decomposed cream
pH	6.0	8.9
Sodium nitro-prusside test	+	++
Mercaptans	−	−
Sulfates	+	++
Sulfides	+	+++

ganoleptically. The data given in table 4 indicate definitely that odor production is not dependent on the amount of protein breakdown as measured by the formol titration. In all five cultures it was found that the defects were much more pronounced and intense when cream was used as a substrate. The quantitative tests run on the cream cultures indicated that some sulfur compounds may be involved in the odor production. Trace amounts of mercaptans were found in two of the cultures. In addition, several of the cultures were able to produce small amounts of H_2S from the cream.

Another interesting observation during the course of the experiment was made on the distillates of the various cream cultures. It was found on completion of the distillation process that the distillates all had a common odor resembling heavily browned toast. The odor was one that would be associated with the heating of an organic mixture. However, it was not suggestive of severe burning or charring nor was it in any way typical of the culture distilled. On standing in the refrigerator for two or three days in a stoppered flask it was found that an odor appeared which closely resembled or was identical with that present in the original cream culture. No attempt was made to determine the reason for such an observation, but it was

TABLE 4

Effect of bacterial cultures on cream and skim milk
(After 10 days at 8° C.)

Culture	Medium	Acidity*	Formol*	Criticism	H_2S	Mercaptans
Control	Cream	1.5	1.7	Cooked	–	–
	Skim	2.3	2.8	Cooked	†	†
P28	Cream	3.3	3.0	Very putrid	–	–
	Skim	3.6	3.9	Sl. putrid	†	†
P70	Cream	3.7	2.5	Decaying cabbage	+	Trace
	Skim	3.2	6.5	Sl. putrid	†	†
P78	Cream	5.25	3.35	Putrid—limburger	–	Trace
	Skim	4.50	10.90	Sl. putrid	†	†
P84	Cream	4.1	3.3	Strong cooked corn	+	–
	Skim	3.5	6.9	Sl. cooked corn	†	†
L30	Cream	2.30	1.9	Putrid, caramel	+	–
	Skim	3.25	2.4	V. sl. putrid	†	†

* Results expressed in milliliters of N/10 NaOH to titrate 25 milliliters of the sample.
† No determinations made.

thought to be due to oxidation-reduction processes which might go on during and after the distillation procedure.

DISCUSSION

The results obtained on the counts of both water and butter indicate that there is a portion of the flora in these samples which may remain unmeasured when using mesophilic incubation temperatures. The results obtained when using 37° C. incubation and the presumptive coliform test with brilliant green-lactose-bile broth indicate the inadequacy of public health methods of analysis for creamery water supplies. The potability of most of the waters would scarcely be questioned, but the unsuitability of several of them for creamery work has been demonstrated. A satisfactory water supply is one which is relatively free from all bacteria and particularly those types which are able to attack milk constituents at low temperatures. Therefore, it is imperative to use methods which will measure this flora adequately.

The fact that butter may contain a large number of cryophilic organisms is not surprising, for frequently storage at temperatures just above freezing serves as an "enrichment" process for the growth of these types at the expense of others requiring higher temperatures. Contamination of water is not so important from the quantitative as from the qualitative standpoint. However, in the past, the magnitude of count has been constantly emphasized, whereas a low count water may have been considered satisfactory and unimportant so far as dairy products were concerned. It should be recognized, however, that such a water may be a source of few but very important organisms of the lipolytic and caseolytic types, which may be able to grow at low temperatures.

A majority of the isolated cultures showed marked lipolytic and/or caseolytic action, which points to the possibility of their ability to cause trouble. The observation that some samples contained a large number of cryophiles which were inert on differential media does not decrease the significance of the count. When using skim milk agar, the measurement of caseolysis may be a function of temperature as has been noted by Sarkaria and Hammer (33). Simply because an organism does not produce any visible change on casein at low temperatures does not mean that it is harmless to butter keeping quality. It has already been demonstrated that intensive odor production may occur in cream without extensive proteolysis. There are a number of the minor constituents of milk which are proteins or protein-like in nature and which may be attacked by bacteria.

The development of more typical and intense odors in cream as compared with skim milk is an indication that the deterioration may be intimately connected with the fat. In this connection, there appear to be several possibilities. The pure triglyceride itself may be responsible or some substance associated with it—the phospholipids or the fat globule membrane. However, the distillation studies indicate that the material involved is a protein or protein-like in nature since the sulfur in the medium is one of the constituents affected. It would, therefore, seem that the protein-like materials in the fat globule membrane and the phospholipid fraction are most likely involved. In addition, the odor defects produced are suggestive of a proteolytic change.

SUMMARY

1. In plating out creamery water samples and butter samples on two differential media, it was found that 20° C. incubation gave, in most cases, the highest counts. However, 8° C. incubation yielded counts that were of considerable magnitude. In no sample did 37° C. incubation produce maximum total counts.

2. Caseolytic and lipolytic cultures capable of vigorous growth at 8° C. were isolated and purified. Of the forty-one cultures studied, twenty-eight belonged to the genus *Pseudomonas*, five to the genus *Flavobacterium*, six were species of *Alcaligenes*, one was classified as an *Achromobacter*, and one was a non-lactose-fermenting yeast.

3. Incubation studies using sterile cream inoculated with pure cultures showed that a large majority of these cultures were capable of causing extensive deterioration as measured by odor production. The production of odor defects typical of each culture depended on the temperature and the time of incubation.

4. The effect of five pure cultures on cream and skim milk was observed organoleptically and measured by acidity and formol titration. It was found that the intensity of the odor production was not correlated with extensive protein deterioration, as measured by the formol titration. It

was also observed that odor production was more intense in cream than in skim milk. Positive qualitative tests for hydrogen sulfide and the presence of mercaptans were obtained during the process of distillation of several of the cultured cream samples.

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MEASURING DETERGENCY FUNCTIONS AS AFFECTED BY VARIOUS DETERGENTS AND PROCEDURES AGAINST MILK FILMS BY APPLICATION OF A MECHANICAL WASHING APPARATUS*

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The detergency qualities of washing powders have in most instances been determined by theoretical attributes based on chemical constituents and reactions. However, investigators have also used mechanical washing devices to measure the efficiency of detergents. Schwartz and Gilmore (12) studied detergency from glass dishes of a prepared soil analogous to that normally formed from food sources, using a standard mechanical dishwasher and presented averages of light transmission readings obtained by use of a Zeiss photometer.

Gilcrease and O'Brien (4) developed a functional test, involving washing apparatus for microscopic slides and used a photoelectric colorimeter to evaluate various products marketed for dishwashing. A standard soil of similar constituency to that frequently encountered in dishwashing was also used by these investigators for studying detergent efficiency.

Scales and Kemp (10) prepared sheets of metal with an adhesive milk film by exposing 3-inch squares of tinned copper to milk just below the boiling point. After drying 4 days at room temperature the metal squares were washed by dipping in washing solution at 120° F. for one minute without agitation after which the slides were moved back and forth for one minute to create circulation of the solution across the surface.

Numerous investigations on detergency of various dairy washing products have been made. Alkaline powders have been generally accepted and detergency factors applying to these products have been extensively reported. Generally alkaline products have been evaluated for detergency qualities on the basis of pH and sodium oxide content, and for qualities of water softening, wetting, dispersing and emulsifying action. An excellent review of early work on alkaline detergents has been done by Barnum, Lucas and Hartsuch (2). However, alkaline detergents have not been completely satisfactory for dairy utensil washing. Sommer (13) reports that sodium hydroxide and carbonate washing powders cause granular precipitates that tend to cling to the surface of equipment; while Parker and Johnson (7)

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associate alkaline detergents with formation of milk stone on equipment. Also alkaline detergents have not been found suitable for flush-washing cream separators due to causing excessive sliming within the separator bowl (5).

The use of acid detergents for the dairy industry was first reported in 1940 by Scales and Kemp (11). Parker (8) confirmed excellent cleaning obtained with acid.

Cleaning trials with synthetic organic detergents were first reported by Scales in 1939 (10). Rapid application has since been made of these products in conjunction with alkaline and acid detergents in the dairy industry.

Sodium hexametaphosphate and sodium tetraphosphate have been used industrially (9, 12) as mineral sequestering agents, and have mainly been used in detergency in combination with alkaline powders to inhibit calcium reaction by tying up the calcium ion and thus preventing the formation of calcium precipitation of casein or carbonate.

A neutral or near-neutral detergent in the nature of a *wetting agent* and metaphosphate was found by the author (5) to effect improved detergency over a wetting agent detergent alone for flush-washing cream separators.

The condition of the water with respect to detergency has received attention. Water-softening has been a recognized requirement of alkaline washing powders; while wetting agent detergents have also been shown to effect mineral precipitation in hard water when used in the quantity required for detergency (5, 6).

In view of the many types of dairy detergents that are available, and in consideration of the difficulty in maintaining utensils clean and free of milk and mineral residues, it seemed desirable to apply laboratory washing tests to determine comparative washing performance and conditions under which several of these products could be used most effectively.

PROCEDURE

Under practical washing conditions glass surfaces were repeatedly coated with raw milk films and after each washing treatment the glass was examined for light transmission to determine residual filming by means of a Cenco-Sheard Spectrophotelometer.

Five detergents of different type were selected for use to determine their detergency under varying conditions of use.

Washing trials were made to measure the detergency obtained when the sequence in washing technique involved:

(a) Prerinse, wash, after-rinse.
(b) No prerinse, wash, after-rinse.
(c) Washing only.
(d) Prerinsing with water of different hardness.
(e) After-rinse using soft water.

(f) After-rinse using water treated with sodium metaphosphate and sodium metaphosphate–wetting agent detergent.

Unetched, clean, 3-inch squares of glass were coated with raw milk films by twice immersing in well-mixed raw whole milk held at 95° F. The coated slides were placed on a frame at approximately 45° angle to permit draining and drying for a period of 5 to 10 minutes before washing.

Washing was accomplished by use of a motor-impelled bar to which the glass squares were attached in a manner that each was washed in a separate water bath containing 1500 ml. of different washing solutions. Description of this apparatus is shown in figure 1.

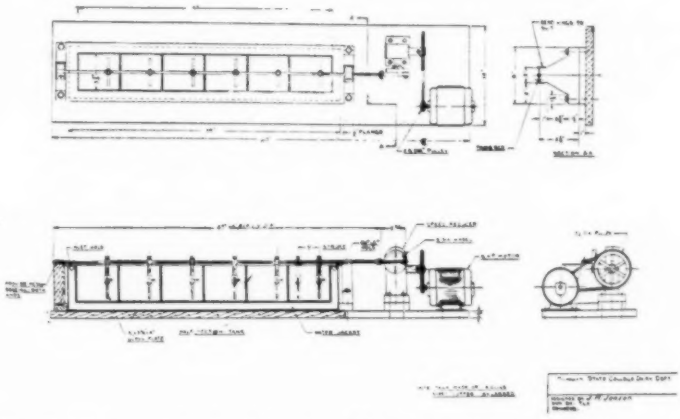

FIG. 1. Diagrammatic drawing of washing apparatus for glass or metal discs. The author is grateful to Professor A. H. Farrall, of the Department of Agricultural Engineering, for the drawing of the washing apparatus.

The glass squares were propelled at a rate of 45 oscillations per minute, and for one minute washing time preceded by one minute of soaking similar to procedure used by Scales and Kemp (10).

Washing temperatures used were, 95° F. for pre-rinsing, 120° F. for washing and 150° F. for after-rinsing. Prerinsing consisted of impelling the milk-coated glass slides 5 complete cycles through the rinse water at a distance of 3 inches in a manner to force the water across the face of the glass. Rinsing after washing also consisted of 5 complete cycles.

After the glass slides were dried at room temperature, light transmission was measured. Four readings were obtained from each square by placing the corners in the filter position in the spectrophotelometer. Readings were made with adjustment of the entrance slit at 1 mm., exit slit at 20 mm., and 400-mm. wave length. The galvanometer was adjusted for zero reading with no light transmitted, and for 100 with light transmitted through a clean glass of the same quality as that used for the washing trials.

The pH of washing solutions was determined by use of a Beckman pH meter. No other chemical analyses were made of the detergents used.

The tap water used in the washing and rinsing processes contained 300–320 p.p.m. of hardness as determined by soap titration (1), and the zeolite-softened water contained less than 30 p.p.m. hardness. Metaphosphate treated pre-rinse water, as used in figure 4 was determined by calculation based on a requirement of 1.25 g. sodium metaphosphate per grain of hardness in 100 gallons of water (5).

RESULTS

The pH of solutions of detergents used. Five proprietary detergents, representing those most commonly found among dairy farm utensil cleaners were used in this study. They include (a) an alkali with wetting agent; (b) an alkali with neutral polyphosphate salt; (c) an acid cleaner; (d) a wetting agent and (e) a near neutral polyphosphate salt with a wetting agent. The specific product used for each group was selected without previous evaluation as to its detergency value. Therefore, it is entirely possible that the product selected for study was not necessarily the best in the group. However, it is believed that these are representative of the several types of cleaners available for dairy utensil washing.

TABLE 1

Description of detergency products used in washing trials

Designation of product	pH of 0.25%* solution at 77° F.	Alkaline salts	Neutral polyphosphate salts	Wetting agent†	Acid
		per cent	*per cent*	*per cent*	*per cent*
A	9.87	97	.....	3	.....
B	9.45	80	20	.....	.....
C	2.00	.....	.....	Not known	Not known
D	8.00	.....	.....	100	.....
E	6.50	.....	75	25	.....

* 0.8 per cent solution and 0.15 per cent were used for C and D, respectively.
† Wetting agent powders used contain approximately 60 per cent sodium sulphate. This is included as wetting agent in quantity listed.

The description of the detergents used, which have been designated as A, B, C, D, and E, is presented in table 1. Trials indicated that the pH of a 0.25 per cent solution ranged from a high pH of 9.87 to a low of pH 2.0. Hence, these detergents possess a wide range in reaction which may have an important bearing on their detergency value when used in connection with milk films, the product with which the dairymen must reckon in all dairy utensil cleaning.

Effectiveness of various types of detergent in removing milk films. Glass squares were coated with milk film and washed under controlled conditions,

as explained under procedure, repeatedly 14 days using the various types of detergent described in table 1. The specific data by days are presented in figure 2 whereas averages are presented in figure 3. From figure 2 it will be noted that the most effective detergency occurred under all conditions of washing when detergent E, the near-neutral mixture of wetting agent and metaphosphate, was used.

The removal of milk film with detergent D, the slightly alkaline wetting agent, was more complete than with either of the strictly alkaline or acid detergents. However, the results secured when employing the usual washing procedure of prerinsing, followed by solution washing and rinsing with hot tap water afterward, were no better than when a similar procedure was used with alkaline detergent A. An improvement resulted when a washing procedure that differed from the usual practice was used, as is shown later in this article.

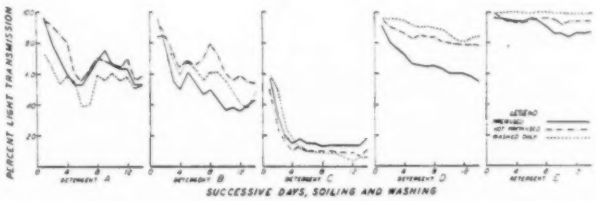

FIG. 2. Effect of repeated washing of milk-coated glass with five different detergents in tap water at 300 to 320 p.p.m. hardness. Washing procedures included (a) prerinsing using 95° F. water, washing with 120° F. solution and after rinsing with 150° F. water; (b) washing with 120° F. solution and rinsing with 150° F. water with no prerinse; (c) washed only using 120° F. solution without prerinsing or after-rinsing.

Acid detergent C had inferior detergency qualities and appeared to cause protein precipitation on the glass surface. The poor detergency could possibly be accounted for by the low washing temperature (120° F.) and low pH at which these washing trials were conducted, although the amount and temperature directed by the manufacturer were used.

Filming on the glass did not always develop with regular intensity, but as measured by spectrophotometer reading, showed occasional recovery in light transmission. The alkaline detergents A and B, figure 2, gave rise to greater fluctuation in spectrophotometer readings than the other detergents used. This variation in filming gave evidence of detergency properties that were inadequate to remove the inner and more tenaciously bonded films; but sufficient to remove the outer and more loosely held accretions.

The superior washing results that were secured with near-neutral detergent E definitely indicated that detergency of milk films was not contingent upon chemical reaction of alkalinity or acidity, but on basic properties of wetting, emulsifying and dispersing. A properly combined compound con-

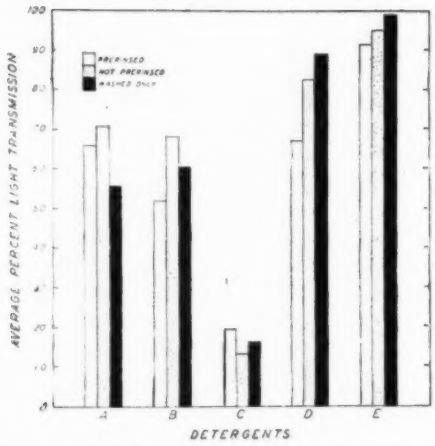

FIG. 3. Average per cent light transmission of 14 repeated washing trials when 5 different detergents were used in tap water at 300 to 320 p.p.m. hardness. The washing procedures included (a) *prerinsing*, washing and after-rinsing; (b) washing, after-rinsing, but not prerinsed; (c) washing only without prerinsing or after-rinsing.

sisting of sufficient wetting agent for fat emulsification and wetting action, plus a near-neutral polyphosphate to perform the function of dispersing the milk solids, while also suppressing mineral salt precipitation, appeared to harmonize in a manner to effect superior detergency on raw milk films. Although detergency qualities were possessed by the alkaline and acid products used in these trials, it was altogether probable that alkalinity or acidity adversely affected the adhering condition of milk protein. At least the high detergency secured with the slightly alkaline product D and the near-neutral product E would indicate that products possessing physical detergency qualities (11) rather than qualities depending upon chemical reaction were most suitable for raw milk film removal.

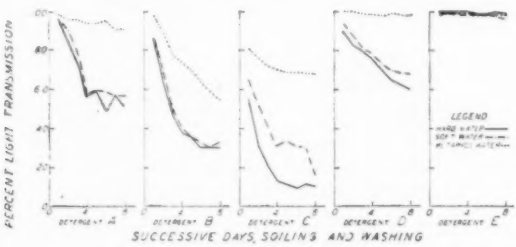

FIG. 4. The effect on light transmission when the quality of prerinse water was varied to include (a) hard water at 300 to 320 p.p.m. hardness; (b) zeolite-softened water at less than 20 p.p.m. hardness; and (c) metaphosphate water treated in excess of 0 hardness.

Influence of prerinsing on removal of milk film. In the series of 14 washings made wherein the milk-coated glass squares were washed without prerinsing, outstanding improvement resulted with all detergents except C, as shown by figures 2, 3, 5 and 6. Especially outstanding was the improvement evident with products B and D.

These results were of special interest inasmuch as prerinsing has been considered a most necessary function under all washing conditions to prevent the forming of milkstone as well as to preserve the quality of the washing solution.

As a means of determining whether the hardness or the condition of the prerinsing water influenced the difference in film adherence, prerinsing was conducted in hard water, soft water and hard water treated with excess sodium metaphosphate, in sufficient quantity to account for 350 p.p.m. hardness in 300–320 p.p.m. water. Since sodium metaphosphate has not been

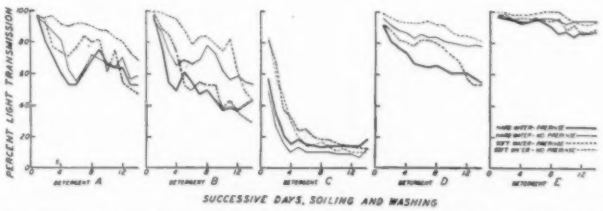

FIG. 5. Effect of hardness of water used for the final rinse on light transmission when milk-coated glass slides were repeatedly washed in 5 different detergent solutions, with and without prerinsing. Hard water at 300 to 320 p.p.m. and zeolite-softened water at less than 30 p.p.m. were used for final rinse.

considered a detergent, the difference obtained in detergency value when metaphosphate prerinse was used could be regarded as being attributed to a change in the nature of the milk film due to the action of metaphosphate on the milk bound calcium. The influence of these conditions is presented in figure 4, and shows that film removal was only slightly improved when soft water was used for prerinsing over hard water with all detergents except C where substantial improvement occurred. The influence of excess metaphosphate solution for prerinsing resulted in exceptionally high improvement in detergency for all products except E. Since product E gave practically complete film removal under all prerinsing conditions this product could hardly be improved. However, detergent D gave similarly high spectro-photometer readings when prerinsing with the metaphosphate solution.

These results substantiate the soundness of washing certain utensils like cream separators and milking machines with wetting agent detergents by flush washing procedures without prerinsing except as required to flush excess cream from separator parts (3).

It appeared likely that untreated water reacted with milk constituents as a result of the prerinse to increase the fixing quality of the milk film. Since detergency was highly improved with metaphosphate added to the rinsing water it was conjectured that the film fixation quality of normal milk and water was related to the chemical and physical behavior of calcium and casein.

A practical application of prerinsing with near-neutral polyphosphate salt solutions could possibly be developed for better results with mechanical washing of milk cans.

Influence of detergency when washed without prerinse and after-rinse. Washing trials were also conducted to determine the influence of not rinsing after washing on the cleanliness obtained on glass slides washed with the various detergents. These results are also presented in figures 2 and 3.

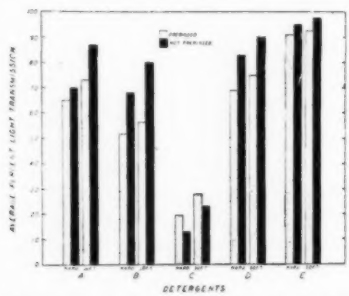

FIG. 6. The effect of hardness of water used for the final rinse on the average light transmission readings, obtained from 14 successive washing trials with and without prerinsing.

Oddly enough highest detergency was secured for washing products D and E, slightly alkaline and near-neutral detergents respectively, when no rinsing treatment was applied either before or after washing. The acid detergent also indicated slight improvement when not rinsed following the washing treatment. The alkaline detergents, however, gave materially improved detergency values when a final rinse with clear water at 150° F. was applied.

Influence of soft water in final rinse on washing results. Washing was conducted employing soft water for the final rinse under conditions wherein prerinsing was used on one set of slides, but not on the other. To simplify a comparison of the results when rinsing with soft water and hard water under similar washing conditions, the results are presented in figures 5 and 6. The *hard water* washing data being the same as shown in figures 2 and 3. Fairly high improvement was shown in favor of soft water for rinsing after washing for all the detergents, but only scant improvement again was possible for detergent E, because of its high detergency value when hard water

TABLE 2

Effect of sodium metaphosphate in final rinse water at 150° F. on light transmission of glass slides when washed with neutral metaphosphate–wetting agent detergent at 0.25% concentration. No pre-rinse

Per cent sodium metaphosphate salt in rinse solution	Per cent light transmission									
	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day
0.05	87	93	92	98	98	97	95	96	95	96
0.10	97	96	95	97	96	96	95	95	95	95
0.15	98	96	96	96	97	97	98	96	96	97

* Average of two trials.

was used. Attention is also again called to the high improvement in detergency when no prerinse was used. Under such a washing condition products A and D gave highly improved detergency.

Effect of adjusting final rinse with sodium metaphosphate and sodium metaphosphate plus wetting agent. The results obtained when glass slides were washed with a sodium metaphosphate–wetting agent mixture and not rinsed, as shown in table 2, tended to indicate that the remaining surface retained a protective layer to which the milk film did not adhere as firmly as on a surface rinsed free of such a film. Since rinsing after washing with hot water is necessary as a sanitizing measure, it was considered feasible that better detergency conditions could be maintained, providing the rinsing water contained a certain amount of metaphosphate or possibly metaphosphate–wetting agent detergent. Trials were, therefore, made on washing milk-coated films with neutral sodium phosphate–wetting agent detergent E at 120° F. and rinsing with 150° F. water containing 0.05, 0.10 and 0.15 per cent, respectively, of sodium metaphosphate in one trial and the same quantities of detergent E in another. The results are shown in tables 2 and 3.

Results in table 2 show that when the final rinsing water contained sodium metaphosphate in percentages of 0.10 and 0.15 consistently high light transmission was obtained, with some increase in this respect favoring the higher quantity used. When only 0.05 per cent was used the rinsing solution

TABLE 3

Effect of sodium metaphosphate-wetting agent detergent in final rinse water at 150° F. on light transmission of glass slides when washed with similar detergent at 0.25% concentration. No pre-rinse

Per cent sodium metaphosphate-wetting agent detergent in rinse solution	Per cent light transmission									
	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day
0.05	90	95	89	83	89	89	88	89	88	87
0.10	99	99	99	98	97	97	98	97	98	97
0.15	99	100	100	100	100	100	99	100	100	99

appeared slightly turbid, indicating an unstable calcium condition. Although this condition occurred in all solutions the first washing was the most measurably affected. Two trials were made to verify this condition and the results presented are their averages.

When detergent E was used at 0.10 and 0.15 per cent levels in the rinsing water higher light transmissions were observed than when sodium metaphosphate at these percentages were used. Also the 0.15 per cent quantity gave higher light transmission and slightly better results than when 0.10 per cent was used.

When only 0.05 per cent of detergent E was added to the final rinsing water turbidity occurred, along with lower light transmission. This condition was apparently due to an insufficient quantity of metaphosphate to inhibit calcium reaction with the sodium sulphate accompanying the wetting agent.

Consistently high light transmission observed adequate cleaning when quantities of detergent E were used in rinsing water again suggested that a protecting film of wetting agent and sodium metaphosphate adhered to the surface and prevented the more tenacious bond otherwise formed by milk.

SUMMARY

Detergency studies were made on various types of washing products. These were made by washing raw milk films from glass surfaces by a devised mechanical apparatus and measuring result in terms of light transmission by use of a Cenco-Sheard spectrophotelometer.

An appreciable difference was observed in detergency as affected by detergent material and variations in washing procedure that was measured by light transmission readings. Highest detergency values were secured with solutions prepared of near-neutral wetting agent and metaphosphate mixtures. Next in order of detergency were slightly alkaline wetting agent detergent, alkaline salts containing wetting agent, alkaline salts containing metaphosphate and acid detergent solution which gave lowest and entirely inadequate detergency.

Prerinsing effects demonstrated depressive detergency action with both hard and soft water with all detergents except acid. Better detergency was secured with soft water than with hard water. Highly improved detergency was attained when prerinsing with water containing metaphosphate in slight excess of that required for sequestration of water hardness.

After rinsing effects demonstrated improved detergency with alkaline detergents when hard and soft water were used at 150° F. Depressed detergency occurred with acid, wetting agent and wetting agent plus metaphosphate detergents. However, soft water for final rinse gave better results than hard water.

When wetting agent–metaphosphate detergent was used and the final

rinse contained 0.10 and 0.15 per cent metaphosphate in water containing 300 to 320 p.p.m. hardness, high light-transmission readings were maintained throughout repeated washing trials. Highest and practically complete detergency as measured by light transmission occurred when 0.10 and 0.15 per cent wetting agent–metaphosphate detergents were usd in the final rinse.

ACKNOWLEDGMENT

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THE RELATIVE IMPORTANCE OF HIGH TEMPERATURE AND HIGH HUMIDITY AS FACTORS INFLUENCING RESPIRATION RATE, BODY TEMPERATURE, AND PULSE RATE OF DAIRY COWS

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Results of various studies (5, 7, 8, 11) have focused attention on the importance of summer climatic conditions as factors affecting the production of dairy cattle. Experimental results have shown, in general, a reduction of the fat percentage of the milk and, in some cases, a decrease in the quantity of milk produced. Two primary reasons are advanced (9, 10, 11, 12) for decreases in production during summer months. One is the lack of an abundant supply of green succulent milk-producing feed such as is supplied by an excellent pasture. The second is the inability of the cow to dissipate heat at a fast enough rate (2, 6) to keep up with the heat-producing effect of existing climatic conditions. As a result, various studies (3, 8, 9, 10, 11, 12) have shown that cows develop greatly accelerated respiration rates and higher body temperatures. One recently reported study of Jersey cows in Louisiana (4) showed correlations between air temperature and respiration rate of 0.77 and between air temperature and body temperature of 0.57. When air temperatures were below 70° F. the correlation was insignificant.

Reports on two studies (1, 10) show that high humidity, in addition to high temperature, may be an important factor in causing lower production and increases in respiration rate and in body temperature. The data are rather scanty, however, and this was one reason why the present investigation was initiated. Louisiana conditions in summer are such that relatively wide variations occur in both temperature and humidity, thus affording a good environment for testing the relative importance of these two climatic factors in causing changes in respiration rate, pulse rate and body temperature of dairy cows.

PROCEDURE

Data used in the present study were secured from milking cows of the Louisiana State University dairy herd. The cows were handled in two separate dairy units and each unit included both Jersey and Holstein cows. In 1944 there were 36 Holsteins and 16 Jerseys, while in 1945 observations were made on 41 Holsteins and 27 Jerseys.

Respiration rates were secured from counts made of flank movements and body temperatures from readings made with veterinary thermometers inserted approximately three inches into the rectum. Pulse rates were secured

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by placing tips of fingers next to coccygeal arteries on under side of tail. In most cases respiration and pulse rates were checked by two people and when there was a lack of agreement a third count was made. These records were secured from 10 to 30 minutes after the cows entered the milking barn (at approximately 3:00 P.M.) and before they were fed grain.

During 1944 records were secured on consecutive days twice weekly, starting on August 28 and ending on October 14. In 1945 each herd was observed on 15 different days, with these days falling between July 16 and August 3 for one herd and between August 6 and August 24 for the other.

A sling psychrometer was used to secure wet- and dry-bulb temperature records at the time of each observation. Appropriate standard weather bureau tables were used to determine relative humidity from the readings secured.

RESULTS

The atmospheric temperature and relative humidity prevailing during the periods of observation showed fluctuations as indicated in table 1. Response of the milking cows to these atmospheric conditions is also shown and their body reactions indicate relatively large increases from those considered normal, 101.1° F. (4) for body temperature, and 22 for respirations per minute. This would indicate that the atmospheric conditions prevailing during the course of the experiment departed sufficiently from normal to demonstrate just what effect variations in summer atmospheric conditions have on body temperature, respiration rate, and pulse rate of dairy cows.

TABLE 1

Summary of air temperature, relative humidity, body temperature, respiration rate, and pulse rate for periods covered in the experiment

	Periods of observation					
	1944			1945		
	Range	Mean	Standard deviation	Range	Mean	Standard deviation
Air temperature (°F.)	65–93	85.1	6.17	75–91	85.6	4.75
Relative humidity (%)	27–91	56.8	14.06	51–91	73.5	10.00
Body (rectal) temperature (°F.)						
Holsteins	100.2–106.5	103.31	1.27	100.0–106.0	103.46	1.22
Jerseys	100.3–105.6	102.60		99.0–105.9	102.71	
Respirations per minute						
Holsteins	21–129	67.4	24.0	28–129	80.4	20.2
Jerseys	22–128	69.9		23–143	75.9	
Pulse rate per minute						
Holsteins	40–91	67.7	6.66	32–94	70.6	7.22
Jerseys	50–99	65.9		53–99	70.0	

The analysis of covariance, multiple correlation, and partial correlation (13) were utilized for the analysis of the data secured in this study. It was first necessary to use covariance to remove from the data the variation due to differences between the two herds caused by the plan of handling the University cattle as two dairy units. This was found to be an important source of variation for both years. Next, differences between breeds within the herds were removed from the data. For body temperature this was an important source of variations as is indicated from the averages given for the two breeds, as shown in table 1. Respiration and pulse rate differences

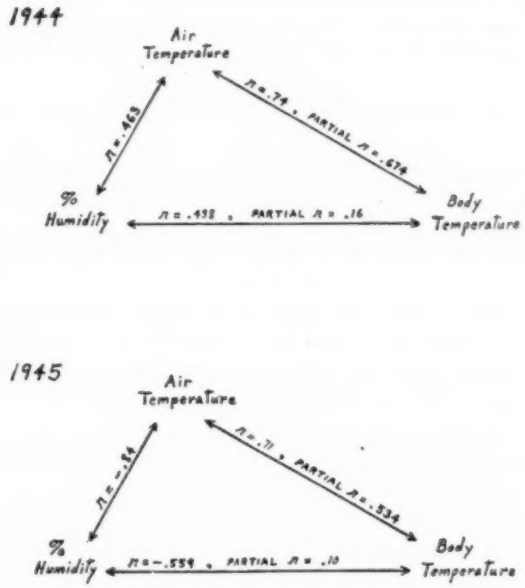

FIG. 1. Correlations between air temperature, relative humidity, and body temperature of cows on an intra-herd and intra-breed basis.

between breeds were only slightly important. After removing variance in data due to herd and breed differences, the final measurements in terms of correlation coefficients and regression equations are on an intra-herd and intra-breed basis and are thus appropriate for predicting what would happen in an individual dairy herd consisting of just one breed of cattle.

Body temperature. Relationships between air temperature, relative humidity, and body temperature on an intra-herd and intra-breed basis can be seen best by examining figure 1. This diagrammatic presentation indicates by correlation coefficients the relationship between the three variables. Of special interest is the positive correlation (r) between air temperature

and relative humidity in 1944 and the negative one between these same two variables for 1945. The reversal in this relationship is attributable to sampling variation caused by the choice of days used for observation during the two years.

The correlation coefficients of 0.74 and 0.71 between air temperature and body temperature for the two respective years are relatively high and surprisingly alike, in view of the reversal in behavior of relative humidity in relation to air temperature for the two years. The correlation between relative humidity and body temperature, on the other hand, takes a reversal in form, being 0.438 for 1944 and −0.559 for 1945.

Using partial correlation, whereby the effect of one variable can be held constant, helped to remove the apparent discrepancy from the results secured. When this was done and humidity was held constant, the correlation between air temperature and body temperature became 0.674 for 1944 and 0.534 for 1945 (fig. 1). On the other hand, when air temperature was held constant and the relationship between relative humidity and body temperature was measured the correlation coefficient was 0.16 for 1944 and 0.10 for 1945.

By the use of multiple correlation it was found that the R for air temperature and relative humidity times body temperature was 0.748 for 1944 and 0.713 for 1945. These are only a little larger than the simple correlations between air temperature and body temperature. (See figure 1.) The multiple regression equations, having X represent air temperature and Y per cent humidity, were as follows:

For 1944, estimated body temperature = $0.1364\,X + 0.0099\,Y - 9.08$
For 1945, estimated body temperature = $0.1988\,X + 0.0129\,Y - 14.80$

An examination of these regression coefficients shows that those for air temperature are 13 and 15 times as large as are those for per cent humidity. This indicates that every degree increase in air temperature was responsible for from 13 to 15 times as much increase in body temperature as was caused by one per cent increase in relative humidity.

Respiration rate. Figure 2 presents the relationships found between respiration rate, air temperature, and relative humidity. As for body temperature, the relationships between the two years are somewhat confusing because of the reversal in the correlation between air temperature and humidity. Partial correlation coefficients for air temperature and respiration with humidity held constant were 0.748 and 0.353 for the respective years. Only the one for 1945 is appreciably changed from the simple correlations. With air temperature held constant the partial correlation between per cent humidity and respiration rate was −0.06 for 1944 and −0.02 for 1945. Although these coefficients are small they indicate a tendency for respiration to slow up slightly as per cent humidity increases.

Multiple correlation computations of air temperature and per cent

humidity times respiration rate gave values for R of 0.778 for 1944 and 0.591 for 1945. Only the one for 1944 is changed at all from the simple r values shown in figure 2 and that one only slightly. This would indicate that the prediction value of a simple regression equation using changes in air temperature only, would be about as accurate as would a multiple regression equation which considers changes in both air temperature and per cent humidity. A consideration of these multiple regression equations with X

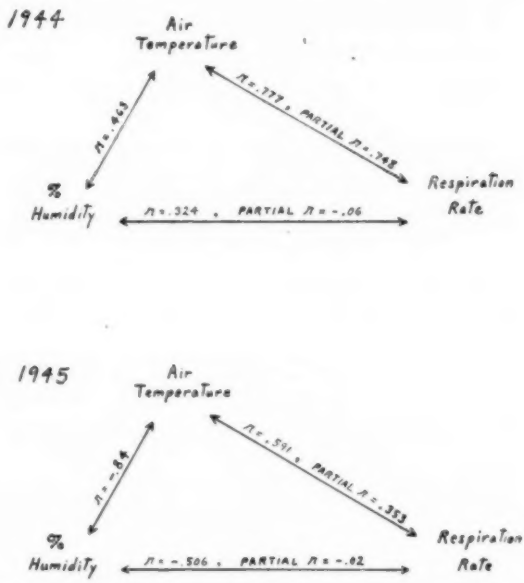

FIG. 2. Correlations between air temperature, relative humidity, and respiration rate of cows on an intra-herd and intra-breed basis.

representing air temperature and Y per cent humidity will also show this to be true:

For 1944, estimated respiration rate = $3.209\ X - 0.0752\ Y - 202.8$
For 1945, " " " = $2.424\ X - 0.0585\ Y - 123.4$

The ratio between the respective coefficients shows that one degree change in air temperature was responsible for from 41 to 43 times as much change in respiration rate as was one per cent change in humidity. Tests of significance showed that the regression coefficient for humidity in 1945 was not sufficiently large to fall within the 5 per cent level of significance. This shows that a simple regression equation considering changes in air temperature only would be appropriate for estimating respiration rates for that year.

Pulse rate. Changes in air temperature apparently had a relatively small effect on pulse rates. Both the simple correlations and partial correlations (fig. 3) are positive and average slightly less than 0.2. On the other hand, the simple correlation of 0.05 between per cent humidity and pulse rate for 1944 became – 0.05 on a partial correlation basis with air temperature held constant. In reverse order, the simple r between these same variables for 1944 of – 0.114 became positive, 0.07, on a partial correlation basis. This reversal in relationship makes it impossible to draw any conclusion, other than to say that changes in humidity had only a small effect in either increasing or lowering pulse rates.

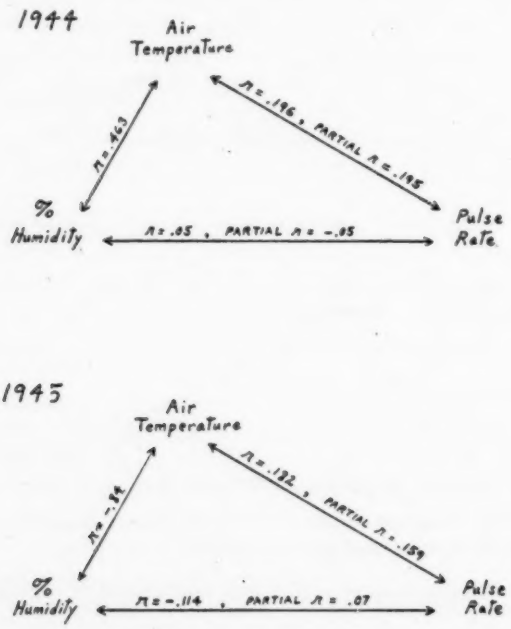

FIG. 3. Correlations between air temperature, relative humidity, and pulse rate of milking cows on an intra-herd and intra-breed basis.

DISCUSSION

Results of this study would indicate that relative humidity plays a minor rôle in comparison to air temperature as a factor influencing body temperature, respiration rate, and pulse rate. In the present study as contrasted to previous ones (1, 10) the effect of humidity was measured by partial correlation; which resulted in a statistic computed on a basis of air temperature held constant. The fact that the data for the two years yielded

similar results is rather significant, in view of the fact that during 1944 there was a high positive correlation between air temperature and relative humidity, while in 1945 a high negative correlation existed between these two variables.

The small negative partial correlations (−0.06 and −0.02) between per cent humidity and respiration are in contrast with the small positive ones (0.16 and 0.10) between humidity and body temperature. It is possible that the slight tendency for an increase in humidity to slow up respiration was responsible for decreasing the rate of heat elimination from the cow's body, thus causing a tendency toward increased body temperature with the rise in per cent humidity. On the other hand, the tendency for increases in humidity to slightly slow up rate of respiration may be of real benefit to the cow. Regardless of the explanation, the present study tends to show that an increase in air temperature is many times more important than is an increase in relative humidity in causing changes in either body temperature or respiration rate. To a lesser degree, the same is true for changes in pulse rate, and in this case the independent effect of humidity gave conflicting results, as shown by a small positive partial correlation for one year and a small negative one for the other.

SUMMARY

Observations made of 36 Holstein and 16 Jersey milking cows during the summer of 1944 and of 41 Holsteins and 27 Jerseys in 1945 revealed the following:

1. Changes in air temperature appeared to be the major cause of increases in body temperature and respiration rate of milking cows.

2. Multiple regression equations indicate that one degree increase in air temperature was responsible for from 13 to 15 times as much increase in body temperature as was an increase of one per cent in humidity.

3. Likewise, one degree change in air temperature caused from 41 to 43 times as much influence on respiration rate as did one per cent change in humidity. On a partial correlation basis (air temperature held constant) an increase in humidity slightly lowered respiration rate. The r values were −0.06 and −0.02.

4. Partial correlations between air temperature and body temperature (humidity held constant) were 0.674 and 0.534.

5. Pulse rates were less affected by either air temperature or relative humidity than was body temperature. Air temperature and pulse rate measured independently of humidity gave r values of 0.195 and 0.159. Humidity and pulse rate (with air temperature constant) gave a value of −0.05 for one year and 0.07 for the other, thus leaving a question as to its real relationship.

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United States Department of Agriculture

ABSTRACTS OF LITERATURE

BOOK REVIEWS

172. Soap in Industry. GEORGIA LEFFINGWELL AND MILTON LESSER. Chemical Publishing Co., Inc., Brooklyn, New York. 1946.

In 181 pages and 23 short chapters the authors have presented the many applications of soaps in a number of industries and their uses in several specific products. Two chapters of special interest to the dairy industry are: Chapter I, Animal Husbandry, and Chapter IX, Milk Production. Several formulas are presented in Chapter I covering the use of soap in compounding, cleaning, and disinfecting preparations for livestock equipment sanitation, wound treatment, external parasite control, insect pest repellents, and liniments for treating lameness of horses. The chapter covering use of soap in milk production offers nothing but admonition to use soap for cleaning walls and floors, and general instruction on plant equipment clean up using hot alkali washing solution. It is pointed out that cleanliness of uniforms or work clothes as well as of personnel is an important factor in milk plant appearance. Each chapter carries a bibliography which should prove useful. L.M.D.

173. Glycerin—Its Industrial and Commercial Applications. GEORGIA LEFFINGWELL AND MILTON LESSER. Chemical Publishing Co., Inc., Brooklyn, New York. 1945.

The authors present a brief history of glycerin from the year of its discovery in 1779 by Scheele up to the present day, pointing out its many industrial uses and touching briefly on its sources and methods of recovery by the saponification of fats. Then follow twenty-seven chapters of specific industrial applications among which many are of interest directly to the dairy industry, such as—Cleaners and Polishes, Lubricants, Packaging Materials, Plastics, Paints and Protective Coatings, Agriculture, Beverages, Foods, and Veterinary Medicine. In the chapter on Foods, items touched upon are: confectionery, sweetening agent, flavoring preparations, vanilla and other extracts, dairy products, etc. Specific reference is made to the use of glycerin in dairy manufactures. Chapter XXVIII, credited to H. Bennett, takes up Glycerin Derivations known as the non-ionic surface active agents and made up of three classes, non-dispersible, dispersible, and water-soluble. Their chemical formulas, chemical and physical properties are given in detail. The last chapter, XXIX, presents a list of 1583 processes and compositions in which glycerin is an ingredient. Throughout the chapters are numerous formulas in which glycerin is an important constituent, and each chapter, except the one on Agriculture, is supplemented with a bibliography

reference. A short appendix contains a table and charts of glycerin physical properties. L.M.D.

BACTERIOLOGY

174. The Formation of Carbon Dioxide by Lactic Acid Bacteria and *Bacillus Licheniformis* and a Cultural Method of Detecting the Process. T. GIBSON AND Y. ABDEL-MALEK, Bacteriology Department, College of Agriculture, Edinburgh, Scotland, Jour. Dairy Res., *14*, 1 & 2: 35–44. 1945.

The amount of CO_2 formed during the fermentation of sugars by the hetero-fermentative lactic acid bacteria was found to depend on several factors: (1) The sugar fermented. Gas is produced more readily from glucose than from lactose, even in the case of active lactose fermenters. (2) The reaction and the buffering capacity of the medium. The optimum initial reaction of the medium is approximately pH 7 and the greater the buffering capacity the more active is the gas production. (3) Factors which occur in plant juices and yeast. The inclusion in the medium of yeast infusion, yeast autolysate or tomato juice had a markedly stimulative effect on the production of CO_2 from sugars. These factors apparently have a specific activating effect on the mechanism of the fermentation. (4) The concentration of sugar, the optimum being about 5%. The formation of carbon dioxide by *Bacillus licheniformis* was found to be influenced in a similar way, but in this case the optimum initial reaction of the medium is in the region of pH 8–9 and the factors of (3) have little effect.

A cultural test was described in which these organisms produce visible gas, thus differentiating them from other lactic acid bacteria or spore-forming bacilli. The media used are 5% glucose in nutrient gelatin or in a mixture of four parts milk and one part nutrient agar, with the addition where necessary of yeast-extract and a plant juice. The cultures are sealed with a layer of solid agar before incubation. S.T.C.

175. The Effect of Acidity on the Production of Diacetyl by Betacocci in Milk. G. A. Cox, Dairy Research Institute (N. Z.), Palmerston North, Nw Zealand. Jour. Dairy Res., *14*, 1 & 2: 28–35. 1945.

The diacetyl production of betacocci isolated from starters, cheese and rye-grass was investigated at pH values ranging from 5.5 to 4.4. The betacocci produced diacetyl and subsequently partially or wholly destroyed it. The rate of growth of the organisms was progressively slower the lower the pH, but at least as much diacetyl was eventually formed at low pH values as at high pH values. This is taken to indicate that there was an alteration in the metabolism of the organisms, the diacetyl-producing power per unit cell increasing with decreasing pH. S.T.C.

BUTTER

176. Cooling Cream for Churning. S. T. Coulter, Univ. of Minn., St. Paul, Minn. Amer. Butter Rev., *7*, No. 9: 278. Sept., 1945.

Cream for churning can be cooled over a surface cooler to churning temperature, according to the author, during all seasons but a few months of winter.

Due to the harder fats in winter, cream cooled by surface cooler should be cooled to about 80 or 90° F. only. The rest of the cooling should be done in a vat to protect the resulting butter from becoming sticky or leaky and to make it more spreadable.

The author points out that cooling cream is only one factor influencing the body quality of butter. P.S.L.

177. New Concept About Butter Revealed. Dr. W. R. Bloor, Univ. of Rochester, Rochester, N. Y. Amer. Butter Rev., *7*, No. 10: 325–326. Oct., 1945.

The chemical composition and nutritional importance of the fatty acids of butter were determined. One volatile, two liquid, and two solid fractions were mixed with a basal ration of whole wheat flour, non-fat dry milk solids and salt and fed to rats. The effects on growth were compared with records obtained by feeding whole butter under similar conditions. To replace the butter Vitamin A destroyed in processing, raw carrots were included in the fatty acid diet. Supplemental vitamin D was given to all animals.

It was concluded that the fatty acid growth-promoting values were found in the liquid or unsaturated fractions, but that the volatile fatty acids were less efficient.

Relationship between body growth and the vitamin A content of the liver were observed. Those rats that were fed liquid fatty acids grew best and stored about twice as much vitamin A in their livers as the rats fed solid fatty acids. The rats that were fed volatile fatty acids grew least and stored least Vitamin A.

The preliminary reports indicate that the chemical composition of a food fat helps to determine the nutritive efficiency of other foods. P.S.L.

178. Greater Butter Values Shown. E. M. Harmon, Natl. Dairy Council, Chicago, Ill. Amer. Butter Rev., *7*, No. 8: 238–239. August, 1945.

Nineteen states cooperating with the U. S. Bureau of Dairying and Office of Experiment Stations have partially completed a study showing that better feeding practices increase vitamin potency in butter.

Reports from fourteen cooperating states show that winter butter, which makes up 36% of all the creamery production in the United States, averages,

per pound, 11,000 units of Vitamin A. Summer butter, making up 64% of all United States butter, averages nearly 18,000 vitamin A units per pound.

By carefully preserving feeds for winter dairy production so as to maintain the carotene, the vitamin A supplied by milk and milk products can be increased. While pasture grasses and roughage are principal sources of carotene, much of the carotene may be lost if care is not taken to preserve it.

It was also shown that storage and time lag in distribution does not materially reduce the content of vitamin A in butter. P.S.L.

CHEESE

179. Contributions to the Study of Rancidity in Canadian Cheddar Cheese. III. A Comparison of the Lipolytic Activity of Slight Rancid and First Grade Samples. O. R. IRVINE, Ont. Agr. College, Guelph, Ont. Sci. Agr., *26*, No. 1: 7. Jan., 1946.

Lipase naturally present in raw milk has been suspected as a cause of rancidity in cheese. In order to learn whether slight rancid cheese would display greater lipase activity than normal, first grade cheese, samples of each type were comminuted into homogenized 37 per cent cream saturated with sucrose and incubated for 12 days at 37° C. Lipase activities as shown by increases in titratable acidity and acids volatile in steam were approximately equal in the two types of samples. It is concluded that the treatment given the fat globules prior to or during manufacture may have a greater influence on the rate of fat hydrolysis than lipase content. O.R.I.

180. Une Nouvelle Modification De La Méthode Au Citrate Pour La Determination De La Matière Étrangère Dans Le Fromage. (A New Modification of the Citrate Method for the Determination of Extraneous Matter in Cheese.) R. THIBODEAU, Dairy School, St. Hyacinthe, Que. Le Quebec Laitier, *5*, No. 1: 8. Jan., 1946.

The citrate method for determining extraneous matter has been modified for use with a 15 g. sample rather than the larger samples previously recommended. A 15 g. sample of cheese is cut fine and then comminuted for one minute in a Waring Blendor with 200 ml. of 10 per cent sodium citrate solution at 150° F. It is then transferred to a conical flask and stirred for about 5 minutes and maintained at 150–160° F. The sample is then filtered through a filter pad held in a special suction funnel with a one-quarter-inch aperture. This filter pad is then dried, mounted and classified according to standards adopted from those of the State of Illinois. O.R.I.

181. A Study of the Balance of Certain Milk Nutrients in the Making of Cheddar, Cheshire and Stilton Cheese, and of Their Fate During the Ripening of the Cheeses. D. V. DEARDEN, K. M. HENRY, J.

HOUSTON, S. K. KON AND S. Y. THOMPSON, National Institute for Research in Dairying, University of Reading, Reading, England. Jour. Dairy Res., *14*, 1 & 2: 100–116. 1945.

Cheshire, Cheddar and Stilton cheeses were made on one occasion from winter, and on another from summer, milk.

The distribution of vitamin A and carotenoids, vitamin B_1, riboflavin and vitamin C between milk, whey and curd was measured during cheese-making.

The fate of these vitamins during ripening was determined.

Some 80% of vitamin A and carotene, 15% of vitamin B_1 and 25% of riboflavin originally present in milk were recovered in the green cheese and persisted throughout ripening.

Vitamin C disappeared progressively during cheese-making and was absent from the cheeses.

Vitamin B_1 and especially riboflavin were recovered in cheese in larger proportions than would be expected from the partition of water between curd and whey, indicating that they were partially present in milk in combination with the coagulable solids.

The concentrations of the various vitamins in milk and the ripe cheeses were respectively for the winter experiment: vitamin A 15 i.u./g. fat and 13 i.u./g. fat; carotenoids 1.8 μg./g. fat and 2.0 μg./g. fat; vitamin B_1 33.5 μg./100 g. and 53 (Cheddar), 44 (Cheshire), and 80 (Stilton) μg/100 g; riboflavin 84 μg./100 g. and 300 (Cheddar), 260 (Cheshire), and 240 (Stilton) μg./100 g. For the summer experiment, the values were: vitamin A 28 i.u./g. fat and 25 i.u./g. fat; carotenoids 10 μg./g. fat and 9–10 μg./g. fat; vitamin B_1 42 μg./100 g. and 55 (Cheddar), 48 (Cheshire), and 75 (Stilton) μg./100 g.; riboflavin 128 μg./100 g. and 330 (Cheddar), 330 (Cheshire), and 360 (Stilton) μg./100 g.

There was no difference between the three types of cheese made in winter in biological value or true digestibility of the proteins for which values of 72 and 98 respectively were obtained at an 8% level of protein intake by the method of Mitchell.

Diets were blended from dried Cheshire, Cheddar, or Stilton cheese and from dried whey to approximate the composition of a sample of dried milk. These diets, when supplemented with iron, copper, and manganese and given as an exclusive diet, produced growth in rats as good as that obtained with the mineralized milk itself. S.T.C.

182. The Heat Resistance of the Bacteriophages of Cheese Starter with Observation on the Estimation of Phage Concentration. AGNES A. NICHOLS AND J. Z. WOLF, National Institute for Research in Dairying, University of Reading, Reading, England. Jour. Dairy Res., *14*, 1 & 2: 93–100. 1945.

The heat resistance, in milk, of bacteriophages attacking strains of lactic streptococci isolated from cheese starters was determined. Active phages

did not usually survive a temperature of 75° C. (167° F.) for 7½ minutes, but many phages were not destroyed by heating for 50–60 min. at 65–70° C. (149–152.6° F.) and most survived at 70° C. (158° F.) for 10–15 min.

S.T.C.

183. Observations of Cheese Starters with Reference to Bacteriophage and the Phage-Organisms Relationships of Strains Isolated. AGNES A. NICHOLS AND J. Z. WOLF, National Institute for Research in Dairying, University of Reading, Reading, England. Jour. Dairy Res., *14*, 1 & 2: 81–93. 1945.

Frequent examination of the mother and bulk starters from several cheese factories during the 1942 season showed bacteriophage to be prevalent in some factories and apparently absent from others. Outbreaks of phage attack could not be correlated with heat treatment of the cheese milk, and were geographically widespread over the country.

The phage-organism relationships of these starter strains and their phage races were studied, and on this basis it was possible to arrive at the relationship and in some cases the identity of some of the strains circulating in commerce. It was found that for the isolation of some phaging strains, milk was a more sensitive medium than broth. Commercial starters appear to be composed of more than one distinct strain. S.T.C.

184. Bacteriophage Infection in Cheese Manufacture. H. R. WHITEHEAD AND G. J. E. HUNTER, Dairy Research Institute (N. Z.), Palmerston North, New Zealand, Jour. Dairy Res., *14*, 1 & 2: 64–80. 1945.

Previous work in bacteriophage infection of starters as a cause of slow acid development in cheese manufacture is reviewed, and the present practices in vogue in New Zealand described. Air-borne phage seems to be the form of infection which is most insidious and most difficult to exclude. The spread of phages as dust or droplet infections seems to explain the gradual increase of trouble with a given starter culture within a single factory and also throughout an entire dairying district.

Besides the air-borne droplet infection, there may be daily reinfection of cheese milk from incompletely sterilized factory and farm equipment which comes into contact with the milk. Phage contamination from factory and farm equipment can be determined by the following method: Samples of 10 to 15 ml. of the milk in question are collected in sterile plugged tubes and pasteurized at 155° F. (68.3° C.) for 10 minutes. The samples are inoculated with three drops of an uninfected culture of the appropriate starter culture and incubated at 37° C. (98.6° F.). Slides are made at intervals, stained and examined under the microscope. In samples which

contain phage, there is gradually increasing growth followed by lysis (indicated by partial or complete disintegration of the organisms).

Air-borne infection of the starter culture is guarded against by: (1) propagation of the starter in a building remote from the cheese factory; (2) maintenance of constant air pressure in the propagating room with filtered air; (3) filtration of air into the cultures through cotton-wool. Sealed vessels with inlets plugged with cotton-wool are used for mother cultures and cans with "water-seal" lids for the bulk starter. S.T.C.

185. Reactions and Properties of Annatto as a Cheese Colour, Part II. C. R. BARNICOT, Dairy Research Institute (N. A.), Palmerston North, New Zealand. Jour. Dairy Res., *14*, 1 & 2: 59–63. 1945.

A Lovibond tintometer was found to be suitable for estimating the coloring power of annatto extracts in dilute alkaline solution. S.T.C.

CONCENTRATED AND DRY MILK: BY-PRODUCTS

186. Reflexions Sur La Législation Francaise Concernant Les Lait Concentrés Et Les Laits En Poudre. (Reflections on French Legislation Dealing with Concentrated and Powdered Milks.) A. TAPERNOUX, L'ecole vétérinaire de Lyon. Le Lait *23*, No. 221–223: 1. Jan.–Mar., 1943.

The fact that concentrated milk products are so highly regarded and widely used in infant nutrition places a special responsibility upon the manufacturer of these products. Standards of composition are reviewed and the proposal made that in the case of whole milk products, the milk used for manufacture contain at least 3.5 per cent fat and 12.35 per cent total solids. French regulations relating to these products are reviewed. O.R.I.

187. The Technique of the Bacteriological Examination of Dried Milks. CONSTANCE HIGGINBOTTOM, Hannah Dairy Research Institute, Kirkhill, Ayrshire, Scotland. Jour. Dairy Res., *14*, 1 & 2: 184–194. 1945.

It is recommended that the bacterial quality of spray-dried powders be determined after reconstitution at 50° C. (122° F.) by the plate count at both 37° C. (98.6° F.) (3 days) and at 30° C. (86° F.) (5 days). S.T.C.

188. The Effect of the Method of Reconstitution and of the Temperature of Incubation on the Plate Count of Spray-Dried Milk Powder. EDITH R. HISCOX, National Institute for Research in Dairying, University of Reading, Reading, England. Jour. Dairy Res., *14*, 1 & 2: 175–183. 1945.

Much higher counts were secured if the dry milk was reconstituted in a

warm fluid rather than in a fluid at room temperature. Ringer solution warmed to 50° C. (122° F.) was found to give satisfactory results. Incubation of plates both at 37° C. (98.6° F.) and 30° C. (86° F.) was recommended. Many samples of powder contained microbacteria which do not grow at 37° C. (98.6° F.). They may so outnumber other organisms such as streptococci and micrococci, which grow at both temperatures, that the presence of the latter may be completely masked by incubation at 30° C. (86° F.). Even a short exposure of the poured plates to indirect sunlight was found to cause a decrease in the plate count. S.T.C.

189. Experiments on the Use of Antioxidants in Spray-Dried Whole-Milk Powder. J. D. FINDLAY AND J. A. B. SMITH, Hannah Dairy Research Institute, Kirkhill, Ayrshire, Scotland, AND C. H. LEA, Low Temperature Research Station, Cambridge, England. Jour. Dairy Res., *14*, 1 & 2: 165–175. 1945.

The following substances were tested for antioxidant activity in laboratory-made spray dried milk powder: ascorbic acid, hydroxy-tetronic and dihydroxymaleic acids, gallic acid, and its esters, citric acid, potassium metabisulphite, gelatin hydrolysate, sodium pyrophosphate and creatinine, sodium hypophosphite, cysteine, tocopherol concentrates and a synthetic chroman and haematoxylin. Ascorbic acid and ethyl gallate proved most promising, ethyl gallate being the more powerful of the two. Ethyl gallate at a concentration of 0.07% increased the storage life of powder in accelerated tests 2½–3 fold. S.T.C.

190. Spray-Dried Milk Powder. Commercial Observations over Two Years of the Effect of High-Temperature Pre-Heating. E. L. CROSSLEY, Alpin and Barrett, Limited, Yeovil, England. Jour. Dairy Res., *14*, 1 & 2: 160–164. 1945.

Pre-heating the milk to a temperature of 190° F. (88° C.) as compared with 165°F. (74° C.) was found to have only a very slight effect on the solubility of the resulting dry milk. The principal difficulty encountered in commercial operation was an increase in bacterial population after the first few hours of the run, due to multiplication in the evaporator and the atomizer feed tank. S.T.C.

191. Solubility of Non-Fat Dry Milk. S. T. COULTER, Univ. of Minn., Amer. Butter Rev., *8*, No. 3: 14. Feb., 1946.

The solubility of roller-dried powder is influenced by a number of factors including these three:

1. Completeness of removal of the dried milk film from the drum at each revolution. The rolls must be smooth and free from pits.

2. Temperature of the roll is dependent primarily upon the steam pressure used, but if this is superheated, reduction of pressure will not reduce temperature as much as might be expected.

3. The thickness of the film and the speed of the roller, even though adjustable, affect the solubility. Precondensing to not more than 18 to 20 per cent solids is a good practice.

A solubility index of 10 ml. is about as good as may be expected with atmospheric roller-dried non-fat milk solids. P.S.L.

DISEASE

192. Les Anémies D'Origine Lactée–Étiologie. (The Anemias Produced by Milk–Etiology.) A. HOUDINIERE. Le Lait. *23*, 221–223. Jan.–Mar., 1943.

Some aspects of this subject are reviewed. O.R.I.

FEEDS AND FEEDING

193. Effect of Storage on Carotene of Plant Extracts. A. R. KEMMERER AND G. S. FRAPS. Texas Agr. Expt. Sta., College Station, Texas. Jour. Ind. Eng. Chem., Ind. Ed., *38*, No. 4: 457–458. April, 1946.

Experiments were conducted to ascertain the relative changes during storage in the percentages of the isomers and other constituents of the crude carotene of plants. Thirteen samples of dried grasses and dried foods stored up to 8 months, showed an increase in the percentage of impurity A in the crude carotene fraction. The percentage of β-carotene in the pure carotene fraction decreased in 6 samples and remained nearly constant in the other 7. The percentage of neo-β-carotene U in the pure carotene increased in 11 samples and that of neo-β-carotene B decreased in 10. The quantity of impurity A increased in dehydrated carrots up to 14 months of storage and in beet greens up to 4 months of storage. In all other samples, there was a decrease in the amount of impurity A. β-carotene, neo-β-carotene U, and neo-β-carotene B decreased in all samples except beet greens, in which there was a slight increase in neo-β-carotene B during the second and fourth months of storage. B.H.W.

194. The Effect of the Diet on Foetal Development. L. R. WALLACE, School of Agriculture, Cambridge. Proc. of Physiol. Society, Jour. Physiol., *104*, 3: 34 p. Jan., 1946.

By feeding some ewes on a much-restricted ration during the last weeks of pregnancy, 144-day-old foetuses were obtained whose mean weight averaged only 57% of those obtained from liberally fed ewes. Under the conditions of this experiment, the growth of flesh (muscle and fat) is depressed

more than the growth of nerve tissue and bone. Within the skeleton there was no, or at most only a slight, differential effect.

As with the major tissues, so with the organs. The alimentary tract was less affected than the heart, the heart less than the lungs and kidneys, and those in turn less than the thymus, spleen and liver. D.E.

FOOD VALUE OF DAIRY PRODUCTS

195. Observations on the Calcium Content of Cow's Milk. E. M. SEMMONS AND E. W. MCHENRY, School of Hygiene, University of Toronto, Toronto, Canada. Canad. Jour. Public Health, *37*, No. 1: 22. Jan., 1946.

The calcium contents of milk samples from a large Toronto dairy, secured from time to time during two months, averaged around 100 mg. per 100 g. This value is 20 per cent less than the amount cited in standard tables of food composition. Pasteurization was shown not to be responsible for the low value found. It would appear that either milk available in the Toronto area has a subnormal calcium content or that the calcium content given for milk in most food tables is erroneous. O.R.I.

196. Comparison of the Growth-Promoting Value for Rats of Butter Fat, of Margarine Fat, and of Vegetable Oils. K. M. HENRY AND S. K. KON, National Institute for Research in Dairying, University of Reading, Reading, England and T. P. HILDITCH AND M. L. MEARA, Department of Industrial Chemistry, University of Liverpool. Jour. Dairy Res., *14*, 1 & 2: 45–48. 1945.

In a series of experiments with rats, the growth-promoting properties of butter fat were compared with those of the solid and liquid fractions of butter fat with margarine and with the following vegetable oils: maize, arachis, cottonseed and soybean. The separation of butter fat into fractions containing a preponderance of glycerides of saturated or unsaturated acids was effected by means of crystallization from acetone. The fats were incorporated into liquid skim milk for feeding.

The authors summarized their results as follows:

(a) No differences were detected between the growth-promoting properties of butter and margarine or of butter fat and deodorized arachis oil; in the latter comparison the arachis oil was more economically used than the butter fat.

(b) No differences were found between butter fat and maize oil alone or containing the solid or liquid fractions of butter fat in the approximate proportions in which they occur in the original fat. The less saturated oils, *i.e.*, maize oil and maize oil + the liquid butter fraction, were more economically used than butter fat and its solid fraction mixed with maize oil.

(c) No differences were observed between the growth-promoting values of butter fat, arachis oil, cottonseed oil or soya-bean oil. The butter fat was rather less well utilized than the less saturated oils, but the differences were not significant.

(d) Poorer growth was observed with the more saturated fraction of butter fat than with the original fat or the liquid fraction.

When butter fat, margarine fat or arachis oil was incorporated in a dry basal diet, no differences were observed in the growth-promoting value of these fats, but the arachis oil was more economically used than the other fats. This finding was not confirmed in a second experiment of longer duration in which poorer growth was observed with the arachis-oil diet, though the economy of gains was the same with all diets.

It is concluded from these experiments that it is unlikely that butter fat possesses superior nutritive properties to those of other fats, and that the more saturated fraction of butter fat is certainly not superior in growth-promoting value to that of the more unsaturated fraction or to more unsaturated vegetable oils. S.T.C.

ICE CREAM

197. Composition of Commercial Ice Cream. E. A. Grant and W. C. Henry, Ontario Research Foundation, Toronto, Canada. Canad. Jour. Public Health, *37*, No. 1: 27. Jan., 1946.

Analysis on 14 samples of ice cream from 5 Ontario cities revealed the following average values: Protein 5.0%; Fat 10.3%; Carbohydrate 17.6%; Calcium 150 mg./100 g; Vitamin A 520 I.U. per 100 g.; Thiamin 65 μg. per 100 g.; Riboflavin 240 μg. per 100 g. O.R.I.

198. The Story of How Vitamin-ed Ice Cream was Developed. Max A. Joffe, Head of Joffe Laboratories, Los Angeles, Calif. Ice Cream Field, *47*, No. 3: March, 1946.

It is stated that the formula whereby vitamins A, D, and E as well as the B complex vitamins—nine in all—are prepared and incorporated in stable form in ice cream was developed in the Joffe Laboratory, and that various aspects of the problem are covered by patent applications.

The author considers ice cream an ideal medium through which vitamins may be made available to the public. One quart of the vitamin-ed ice cream produced under the formula mentioned "furnishes the daily requirements of food supplements and does not act as a medicine" it is claimed. W.C.C.

199. The Effect of Freezing and Cold Storage Upon the Bacterial Content of Egg Melange. C. K. Johns and H. L. Berard, Science

Service, Dom. Dept. of Agr., Ottawa, Canada. Sci. Agr., *26*, No. 1: 34. Jan., 1946.

Freezing egg melange brought about a sharp reduction in the numbers of bacteria present in whole egg melange. In two series of tests involving 44 samples, the average reduction in count was nearly two-thirds. Subsequent storage at 5° F. for 6 months resulted in a little further change in count, although *Escherichia coli* appeared to die off after three months.

In a comparison of methods of estimating bacterial numbers it was found that direct microscopic counts were always lower than the plate counts at 30° C. for some unexplainable reason.

O.R.I.

200. Frosted Foods More Than an Ice Cream Sideline. H. B. GRANT, Publisher of Ice Cream Field and Frosted Food Field. Ice Cream Field, *47*, No. 3: 12. March, 1946.

The author cautions against considering frosted foods a "sideline." He states that in contrast to the aim of the ice cream industry of a billion gallon annual production, which is approximately double present volume, the frozen food industry is aiming for 40 times present volume, *i.e.*, an eleven billion dollar annual business.

It is predicted that soon, complete pre-cooked meals will be frozen. By way of further contrast, it is pointed out that an ice cream retailer speaks of 6 to 10 flavors whereas the frozen food center is stocked with from 25 to 150 different frozen food items. An instance is cited where in one frozen food center, ice cream is sold, along with other frozen food items, at 50 cents per pint.

It is predicted that one super-market will sell more ice cream out of one frozen food cabinet than ordinarily is sold by ten retail shops in the same neighborhood. The ice cream manufacturer should seek to sell package ice cream through these super-markets and he is more apt to do this, the author claims, if he also services the cabinets with frosted foods. An ice cream manufacturer who expects to distribute frosted foods must be prepared to compete with other distributors of frozen foods, but it is concluded that combination of ice cream and frosted foods can be merchandized profitably.

W.C.C.

MILK

201. Le Dosage De La Materière Grasse Des Crèmes. (Determination of Fat in Creams.) J. PIEN, Directeur des Laboratoires de la Laitierie des Fermiers Reunis. Le Lait, *23*, No. 221–223: 18. Jan.–Mar., 1943.

Comparative results on two methods of determining the butter fat con-

tent of cream are given for 10 samples of sweet cream as well as on the same samples after holding for 10 days at room temperature. One industrial method involving a modification of the Gerber test appeared to give as satisfactory results as the Gottlieb centrifugation method. O.R.I.

202. Square Bottles. C. D. KELLEY, Borden Company, Gridley Division, Milwaukee, Wis. Internatl. Assoc. Milk Dealers Bul., *38*, No. 4: 103–106. April, 1946.

The following summary of experiences in the change-over and the use of the square bottle is given:

1. Costs in our change over were minor.
2. No equipment changes necessary in our Milwaukee operation.
3. Breakage no greater than with round bottle.
4. Trippage. Slightly better.
5. Space saving is the outstanding advantage and on the whole the advantages far surpass the disadvantages. E.F.G.

203. Sanitary Standards Subcommittee of the Dairy Industry Committee. T. J. KULLMAN, Committee Member and Production Manager, Bowman Dairy Co., Chicago, Ill. Internatl. Assoc. Milk Dealers Bul., *38*, No. 4: 107–113. April, 1946.

A. Milk storage tank specification in process of development.

B. Sanitary fittings—details given—(not possible to summarize).

C. Shipping cans—details given.

D. Milk transportation—tentative minimum standards now being drawn.

E. Weigh cans and drop tanks—first draft of sanitary standards has been prepared.

F. Milk pumps, homogenizers, electric motors, milking machines, pails and strainers under consideration. E.F.G.

204. The Effect of Temperature of Pre-Heating, of Clarification and of Bacteriological Quality of the Raw Milk on the Keeping Properties of Whole Milk Powder Dried by the Kestner Spray Process. A. T. R. MATTICK AND EDITH R. HISCOS, National Institute for Research in Dairying, University of Reading, E. L. CROSSLEY, Aplin and Barrett, Ltd., Yeovil, C. H. LEA, Low Temperature Research Station, Cambridge, J. D. FINDLAY AND J. A. B. SMITH, Hannah Dairy Research Institute, Kirkhill, Ayr, AND S. Y. THOMPSON AND S. K. KON, National Institute for Research in Dairying, University of Reading, with an appendix by J. W. EDGELL, University of Bristol. Jour. Dairy Res., *14*, 1 & 2: 116–159. 1945.

Part I. Keeping Properties: Factors Influencing Stability. Increasing the pre-heating temperature of the milk from 165 to 190° F. (74 to 88° C.)

before spray-drying greatly improved the resistance of the powder to the development of tallowy "off" flavors on storage. Improvement in the bacteriological quality of the milk supply and more careful control during its passage through the plant produced some improvement in the keeping properties of powders prepared from milk pre-heated at the lower temperature, but had relatively little effect on the keeping properties of the powder when the higher pre-heating temperature was used.

The shapes of the deterioration curves for the various powders showed that the effect of the higher pre-heating temperature and of improvement in the milk supply was to extend the induction period which precedes rapid deterioration. Clarification did not significantly increase the storage life of the powder.

Part II. The Effect of the Various Factors Upon the Bacterial (Plate) Count of the Intermediate Products and of the Final Powder. The plate count of milk powder was significantly reduced by improvement in plant management and in cleaning and improvement in the milk supply. Plate counts of stored powder were higher in plates incubated at 30° C. (86° F.) than in those incubated at 37° C. (98.6° F.). Based on this work, the factors which determine the plate count of dried milk appear to be, in the order of their importance; (1) plant cleanliness and sterility, (2) pre-heating temperature, (3) bacteriological quality of the raw milk supply. The flora surviving in dry milk powder comprises streptococci, micrococci and spore-bearing organisms. When the milk was pre-heated to a temperature of 165° F. (74° C.), micrococci predominated over streptococci, whereas when the milk was pre-heated to 190° F. (88° C.), streptococci predominated and spore bearers were relatively numerous.

Part III. Chemical Enzyme and Vitamin Determinations. The effects of various processing treatments on vitamins A, B, and C and on carotenoids and riboflavin of the various spray-dried milks was studied in the course of a year's storage. Pre-heating the milk to 190° F. (88° C.) was not more deleterious to the vitamins studied than pre-heating to 165° F. (74° C.). The stability on storage of vitamin A and carotenoids and of vitamin C in powders pre-heated to the higher temperature was enhanced. Gas packing afforded further protection. After reconstitution there occurred on standing in the dark in all samples of milk, a certain progressive loss of vitamin C. This was much more marked in the samples pre-heated to 165° F. (74° C.). S.T.C.

205. The Resazurin and Methylene-Blue Tests as a Measure of the Keeping Quality of Milk. E. B. Anderson and G. S. Wilson, Central Laboratory, United Dairies, Ltd., London, and Emergency Public Health Laboratory, Oxford, England. Jour. Dairy Res., *14*, 1 & 2: 21–27. 1945.

A comparison was made of (a) the 10-minute resazurin test, (b) the

1-hour resazurin test, (c) the resazurin test in which the time to reach disk 1 was recorded, (d) the modified methylene-blue test, and (e) a keeping quality test based on taste and alcohol precipitation. Altogether 2588 samples of raw milk were examined during four periods equally spaced throughout the year. The time required for the milk to acquire an abnormal flavor or a positive alcohol test was used as an estimate of the keeping quality. The correlation between the keeping quality test and the various indirect tests were as follows: 10-min. resazurin and K.Q., 0.45: 1-hr. resazurin and K.Q., 0.59: time to reach disk 1, resazurin and K.Q., 0.69 methylene-blue reduction and K.Q., 0.70. It was concluded, therefore, that the methylene-blue test gave the best indirect index of the keeping quality of raw milk, although the time to reach disk 1 in the resazurin test was very nearly as accurate. S.T.C.

206. Temperature Control in the H.T.S.T. Pasteurization Process. J. A. HALL, Physics Division, National Physical Laboratory, Teddington, England. Jour. Dairy Res., *14*, 1 & 2: 1–20. 1945.

An investigation was made into the accuracy and speed of response of temperature measuring instruments suitable for use in the control of H.T.S.T. pasteurization. Thermocouples used in conjunction with a "d.c. amplifier" recorder system was shown to be markedly superior to both vapor-pressure and mercury-in-steel thermometers. The accuracy of temperature measurement was about $\pm 0.3°$ F., as against $\pm 1°$ F.. while the lag constant was about 0.2 seconds as against about 3 seconds. Response to small, rapid, and transient changes of temperature were shown to be greatly improved. The operation of control contract by the thermocouple recorder was found to be reliable to well within the accuracy of calibration, but the other type showed variations of the order $\pm 1°$ F. in addition to the uncertainty of calibration. S.T.C.

207. Daily Advertising Survey. T. P. KENDALL, Nat'l Research Bureau, Inc. Amer. Milk Rev., *7*, No. 9: 345–346. Sept., 1945.

As a result of the survey, a monthly appeal index was charted which permits advertising managers to plot the changes in appeal trends for milk. A "Wheel of Advertising Appeals Among Dairies" was transformed to a chart showing how dairies spent their advertising dollar. It was based upon 250 advertisements of milk covering a nine-month period between July, 1944, and April, 1945.

Percentages appear in following order: (1) Child appeal 15%; (2) Freshness, taste 8%; (3) Health 14%; (4) Institutional 23%; (5) Nutrition 10%; (6) Quality 23%; and (7) Miscellaneous 7%. P.S.L.

208. A Comparison of the Cleaning of Square and Round Milk Bottles Under Regular Commercial Conditions. T. V. Armstrong and L. H. Burgwald, Ohio State Univ., Columbus, Ohio. Amer. Milk Rev., *8*, No. 1: 34, 35, 36, 37. Jan., 1946.

This study was conducted in a city of 300,000 served by about 30 milk distributors. Washed bottles were obtained from seven different makes of washers in nine of the plants in this market, during the months of June, July, August, and September, 1945. The bottles used were collected from typical representative routes.

Two groups were recorded, with and without a chlorine rinse. The plate count method of determining bacterial content was used. Quart and half-pint bottles were examined and the counts were recorded per bottle rather than per ml.

Of the square bottles 4.3 per cent had counts in excess of 1,000 per bottle and 7.3 per cent of the round bottles had a similar count. Of the square bottles 1.1 per cent contained specks of dirt and 5.3 per cent of the round bottles had specks. Of the half pint bottles 9.6 per cent of the square type had counts of 250 or more per bottle while 8.6 per cent of the round bottles were so classified. No visible dirt was observed in any of the square half pints and 8.6 per cent of the round half pints had dirt specks.

The authors conclude that there is no difference in the commercial practicability of cleansing and sterilizing in typical dairy soaker equipment of the returnable square milk bottle and the conventional round bottle.

P.S.L.

209. Marketing Efficiencies as a Part of Our Post-War Economy. Ezra Merrill, Marketing Specialist, H. P. Hood and Sons, Boston, Mass. Amer. Milk Rev., *7*, No. 8: 310, 312. Aug., 1945.

Six economies in distribution practices effected during the war were: Every-other-day daylight retail delivery; six-day delivery of wholesale milk with no call-backs; discontinuation of all special delivery; elimination of bottling pints; split stops limited to not more than two dealers; and deposit charges for bottles, cases and cans. Every-other-day delivery has been the most important economy ever introduced in the distribution of milk. The increase in consumption has had an effect upon this economy since cost per quart goes down as volume goes up.

The adoption of every-other-day delivery reduced the total mileage of the truck by an average of 40 per cent, about 50 cents a day, or 0.0015 per quart. It brought about a great saving in delivery time, this being nearly halved per quart. At the same time, route loads increased nearly 40 per cent.

The author estimates that a return to pre-war practices would mean at

least a one cent per quart increase in price. Increases in price will invite inroads by competitive products such as canned milk. The fluid milk dealers might well consider the continuation of these economies in their post-war plans. P.S.L.

210. Sonic-Soft-Curd Vitamin D Milk. ANONYMOUS. Amer. Milk Rev., 7, No. 8: 286–288. Aug., 1945.

The heart of the system is the sonic oscillator which may be described as consisting of two stainless steel circular plates between which the milk is pumped in a thin film at the bottom and out at the center. Behind one of the stainless steel plates is an oscillating electrical magnet of high voltage that sets up a vibration in the diaphragms, resulting in intense waves of energy at the rate of 360 per second. The result is a breaking up and dispersion of fat globules similar to that in homogenized milk. P.S.L.

211. Certain Defects and Faults in Market Milk By-Products. R. J. RAMSEY, Ramsey Labs., Cleveland, Ohio. Amer. Milk Rev., 7, No. 8: 278, 280, 282, 284, 313. Aug., 1945.

Defects of cream are listed as: (1) poor keeping quality, (2) lipase action, (3) cream plug, (4) cream line, and (5) air incorporation during bottling. The first consideration is high quality milk to start with, and adequate pasteurization. Particular precautions to prevent lipase action include use of hold over milk, preheating before separating, separating at 110° F., care that the cream is not agitated excessively and prompt pasteurization. To avoid cream plug, avoid use of frozen milk or partially churned milk. Avoid extremes in temperature. Cream should not be repasteurized nor should "returns" be used. Cream should be iced for delivery in warm weather.

Soapiness in homogenized milk can be avoided by careful pasteurization before homogenization. Sediment can be eliminated by clarifying. Cooked or chalky flavors occur when pasteurization is above 145° F. for 30 minutes.

Homogenizing cream eliminates cream plug, cream line, adds coloring powers in coffee, lends a richer flavor, and leaves a cleaner bottle after pouring. Twenty per cent cream should be homogenized at about 500# (300–750#) pressure and pasteurized at 150° to 165° F. 30 minutes. Homogenized cream does not whip well.

Cottage cheese is more perishable than fresh milk and only extreme care on the part of the manufacturer and distributor will insure increased consumption. Use only milk of good quality, pasteurizing at 145° F. 30 minutes. Use enough of a good active starter to ripen the cheese in 12 hours. Creaming should be done with care and delivery with dispatch. P.S.L.

212. Wartime Economies in Milk Delivery. DR. LELAND SPENCER, Cornell Univ., Ithaca, N. Y. Amer. Milk Rev., *7*, No. 10: 370. Oct., 1945.

During the war the prices paid for milk by consumers increased much less than did the returns to producers. This was true despite significant advances in wages of persons employed in distribution and in prices of fuel, gasoline, tires, etc.

Two unusual developments which made this possible were: (1) Payment of substantial subsidies by the Federal government. (2) A remarkable lowering of milk distribution costs. The principal change was the adoption of every-other-day service to retail customers. In addition, second calls and special deliveries were eliminated.

The conclusion was drawn that, if pre-war type of delivery were reinstated, using 1945 wage and commision rates, cost of delivering milk to retail customers would increase 1.3 cents per quart, but on 1942 wage and commission rates the increase would be 6.7 cents per quart. On the basis of present wage and commission schedules, return to pre-war methods and loads would reduce earnings of route men $3.00 per week. It would necessitate increase to $\frac{1}{3}$ more routes.

Whether the cost-saving plan of delivery service now in effect or the pre-war type would yield greater returns to producers depends largely upon the attitude of route consumers. Little is known of this factor. P.S.L.

213. Milk Delivery in War and Peace. LELAND SPENCER AND H. ALAN LUKE, Cornell Univ., Amer. Milk Rev., *7*, No. 12: 466, 468, 470, 472, 496, 498. Dec., 1945.

The data for this study were obtained from a survey by questionnaire sent to dealers distributing milk in the New York market. They covered the periods of May, 1942, and October, 1944.

Economies deemed most important effected by the federal government during the war were: (1) Delivery to retail customers was limited to every other day. (2) Elimination of Sunday deliveries to wholesale customers. (3) No special deliveries or call-backs. (4) Advance orders only by wholesale and retail customers. (5) Wholesale customers not allowed to return unsold products.

The entire survey is summarized by the following: Less than one-fourth of the milk distributed in New York City is delivered to consumers' homes. However, in suburban area, more than two-thirds of the milk is delivered to retail customers.

Three-fourths of the milk dealers in New York market sell less than 1,000 quarts a day. Five per cent of the dealers are of this small group. Five dealers sell 100,000 quarts per day and, as a group, handle 55 per cent

of the total volume of the market. The largest distributors have the largest loads and shortest routes. Wholesale routes do not vary so much in volume.

Between May, 1942, and October, 1944, the average quantity of milk delivered per route per day increased 50 per cent, and mileage was reduced 35 per cent. For wholesale deliveries there was a 7 per cent increase in size of loads, but delivery vehicle mileage was reduced 22 per cent. Quantity of milk delivered per mile was increased 54 per cent on retail routes and 42 per cent on wholesale routes. Dealers, who responded to the questionnaire sent them, favored retention of every other day delivery and favored state or federal regulation to effect it.

The authors state that a change of conditions from war to peace could change reactions surveyed at a time when the country was at the peak of its war effort. The success of the war-time practices depended upon the cooperation of consumers and delivery men as well as distributors. P.S.L.

214. Pasteurization by High Temperature—Short Time. W. W. CABANAUGH, York Corp. Amer. Milk Rev., *7*, No. 9: 324, 353, 354. Sept., 1945. Amer. Milk Rev., *7*, No. 10: 378, 380, 382, 384. Oct., 1945.

High-temperature-short-time pasteurization was introduced in the late 1920's. However, it was not until the adoption of the heat exchange plate that the method became widely acceptable. Hot water instead of electricity is used for the final heating of the milk. This, coupled with the fact that pasteurization is done close to the temperature at which cream line becomes affected, made it necessary to develop control apparatus that would positively regulate milk temperature between very narrow limits. This apparatus must also control a milk pump stop in the event below-temperature milk leaves the heater.

Conclusions of the report made on a study of performance of the method showed: 1. Results obtained indicate that heat is the destructive agent and that hot water and electricity are equally efficient in pasteurization of milk. 2. The results indicate an ample margin of safety in time and temperature when the milk is heated to 160° F. and maintained at that temperature for at least fifteen seconds. 3. Operation of milk pump cut-out is necessary as a protection against the treatment of milk at temperatures below 160° F. 4. Hemolytic streptococci evidently survive flash heating better than tubercle bacilli. 5. The York Plate Pasteurizer meets the structural, equipment and operational recommendation set forth in the 1931 report of Committee on Milk Supply Eng. of A.P.H.A. The York equipment includes a thermal limit recorder controller which records the temperature of the milk, leaving the pipeline holder; records the frequency and duration of operation of the flow diversion valve, and operates the flow diversion valve through actuation of a solenoid valve releasing air pressure when it is in diversion flow.

The author reports that there is virtually no limit to the capacity of units, some of them operating for 22 hours daily. The time required for milk to flow from storage tank through the pasteurizer to filler is 1½ minutes.

It is recommended that sufficient storage facilities be provided for at least one hour of continuous operation and that, for long runs when filtering hot, two filters be used. Clarifying or filtering may be done hot or cold.

With high-temperature-short-time pasteurization, thermophylic bacteria do not cause trouble even on prolonged runs. Thermoduric bacteria, however, are not appreciably reduced. Milk retains its raw milk flavor and cream line is comparable to lower temperature holding system.

Advantages of this method include: less labor required for operation and cleaning; time reduction between dumping room and fillers; small amount of floor space required; closed cycle avoids evaporation and re-infection; apparatus is flexible; operation is practically automatic; pasteurization is uniform; cost of pasteurization is lower. P.S.L.

215. Consideration on the Keeping Quality of Pasteurized Milk. L. H. Burgwald and D. V. Josephson, Ohio State Univ., Columbus, Ohio. Amer. Milk Rev., *8*, No. 1: 46–47. Jan., 1946.

A total of 184 bottles of milk, from eight different lots, were tested for keeping quality in these trials. The usual grades of pasteurized milk will stay sweet for seven to twenty-eight days under the normal conditions found in homes equipped with refrigerators. The milk was considered sour when it developed 0.03 per cent or more acidity. Treatment of the milk and temperature of the refrigerator influenced spoilage more than bacterial counts at the beginning of time tests.

Half-pint samples, under similar conditions, stayed sweet an average of 21.8 days. Three sets of quart bottles of milk were taken from each lot, and the first was placed in a refrigerator immediately, the second was exposed at the same temperature for two hours. The average temperature of No. 1 was 43° F. and the set remained sweet for 12.3 days. Set No. 2 had an average temperature of 61.5° F. when the samples were placed in refrigeration and kept at a temperature of 43° F. Set No. 3 had an average temperature of 43.1° F. and remained sweet for an average of 12.4 days. The quart samples were taken out of the refrigerator for five to seven minutes while tests were run. This resulted in an increase in temperature of 2–4° F.

Initial bacteria counts did not indicate milk's potential keeping qualities. One lot of samples had an initial count of 61,000 per ml. and remained sweet for 25 days. Another had 7,150 bacteria per ml. and stayed sweet for only 16 days. There was no appreciable increase in bacteria count up to four days; however, after four days, psychrophilic bacteria increased rapidly. There were no changes noted in flavor until the samples were from four to seven days old. Even then, these were only slight and were not objectionable.

Vitamin C varied considerably in the samples and deteriorated very rapidly. Riboflavin was comparable in all samples and remained practically constant throughout the tests.

Refrigeration temperatures for milk storage should be below 45° F. and preferably at 40° F. P.S.L.

216. Keeping Quality of Milk. L. H. BURGWALD AND D. V. JOSEPHSON, Dept. of Dairy Technology, Ohio State Univ., Columbus, Ohio. The Dairy World, *24*, No. 11: 36. April, 1946.

See Preceding Abstract. F.J.D.

217. Keeping Quality of Pasteurized Milk in N. Y. Area. A. C. DAHLBERG, Dept. Dairy Indus., Cornell Univ., Ithaca, N. Y. Amer. Milk Rev., *7*, No. 10: 372–374. Oct., 1945.

See: JOUR. DAIRY SCI., *28*, No. 10: 779–792. Oct., 1945. P.S.L.

PHYSIOLOGY

218. Reviews of the Progress of Dairy Science. Section A. Physiology of Dairy Cattle. I. Reproduction and Lactation. J. A. B. SMITH, Hannah Dairy Research Institute, Kirkhill, Aryshire, Scotland. Jour. Dairy Res., *14*, 1 & 2: 195–224. 1945.

This is a review of recent literature in the field. 358 references. S.T.C.

MISCELLANEOUS

219. Mise En Evidence Et Isolement Des Enduits Protecteurs De L'Aluminum. (Detecting Aluminum Foil Coatings.) M. H. COUTURIER. Le Lait, *23*, 221–223. Jan.–Mar., 1943.

Coated, laminated aluminum has replaced tin foil as a packaging material for many food products. The resistance of aluminum to certain chemical agents is limited, however, and its use is dependent upon synthetic coatings. Imperfect coating of the metal can be detected by several tests which include: 1. Plunging in aqua regia, 2. Treatment in a 1% solution of bichloride of mercury and a 10% solution of phosphoric acid, 3. Removal with organic solvents. A more rapid test consists of using a 5% solution of bichloride of mercury, unprotected foil being "devoured" in less than one minute. O.R.I.

220. Plans for Dairy Equipment—Post War. A. W. FARRALL, Michigan State College, East Lansing, Mich. Internatl. Assoc. Milk Dealers Bul., *38*, No. 4: 95–102. April, 1946.

Mechanization of many operations will result from difficulty in obtaining

skilled hand labor, to remove human drudgery from plant operation and to improve operating efficiency, as for example with more automatic operating controls.

There is a larger use of conveyors, etc. Stainless steel can now be worked and machined more readily. Chrome plating and heat treatment has helped to lengthen the life of wearing parts. Dairy machines are constructed for closer tolerances resulting in finer machinery with better performance.

Automatic control will be more generally adopted for steam boilers, pasteurizers, refrigeration rooms, etc., resulting in reduction of costs and labor and a more satisfactory product. There will be a more general use of continuous rather than batch processes. Progress will be made in designing more machines to be completely dismantleable for cleaning. More progress will also be made in standardization of sanitary pipes and fittings and other small items.

On the farm the use of the separate milk house will increase and will be an aid to better quality product and easier care of equipment. In warmer climates especially the use of the refrigerated truck will likely increase rapidly.

For the plants there will be greater use of small fully automatic boilers, new can washers for use of new cleaners, water softeners for can washers, improved stainless steel pumps, bottle washers for new type cleaners, the new square bottle and plate heat exchangers. Quick frozen milk and ice cream offer possibilities. The continuous churn offers real possibilities for reduction of cost of processing combined with improvement of quality and uniformity of product.

In refrigeration greater use will be made of low pressure refrigerants. In plants where cost of land is not excessive the single working floor type is increasing with greater emphasis upon the use of new building materials and sanitation.

With the great amount of equipment now in dairy plants, a competent engineer and the training of employees to service equipment will assume greater importance. E.F.G.

221. **The Efficient Use of Fuel.** Prepared under the Direction of the Education Sub-Committee of th Fuel Efficiency Committee of the Ministry of Fuel and Power. Reprinted by permission of the Controller of his Britannic Majesty's Stationery Office. Chemical Publishing Co., Inc., Brooklyn, New York. 1945.

While the text is largely devoted to British practices, the essential fundamentals apply equally well in American practice and their very lucid explanation and development can be readily grasped. It is very complete in coverage of all phases of fuel use. Subjects of pertinent interest are composition and properties of all types of fuel, theories and principles of com-

bustion, equipment used in burning all types of fuel, boiler efficiency and testing, water purification, auxiliary boiler equipment and boiler settings. Steam utilization for industrial processes, central heating, drying and evaporation are given detailed treatment. Also automatic control, the use of various necessary instruments, sampling coal and gases, and their analysis come in for a generous share of consideration. The thirty-four chapters of the book comprises 787 pages of textual matter which is elaborated very amply with 135 tables and over 303 figures, the latter chiefly drawings and a smaller number of graphs. It is important that fuel selection and utilization be given careful consideration in the dairy industry, a considerable user of steam, because of cost of fuel and its efficient use can be a very vital factor in the unit cost of processed milk or a manufactured milk product. It is the feeling of this reviewer that a book of this type could supply the information upon steam generation noticeably lacking in our excellent dairy technological books for much of its material is quite practical so that it may be grasped readily by the non-engineer. L.M.D.

222. How to Improve Coal Utilization and Boiler Efficiency. T. O. PHILLIPS, Bituminous Coal Institute. Amer. Milk Rev., *8*, No. 1: 20–22. Jan., 1946.

It is the problem of the plant manager to select equipment that will burn coal with the best results. Stokers of either the underfeed chaingrate, pulverized coal burners, or spreader types may be used. The gasification of solid fuel and the complete combustion of the gas combine to achieve highest technical efficiency. Proper carbonation of the coal (mixing with air) is an important step.

Prevention of leaks include care that holes in the fire do not occur, that the doors not be opened to check the draft, and that too thin a fuel load not be carried. Incomplete burning of the coal and too much surface moisture should be avoided. Proper coordination of coal-burning equipment with the coal or coals which it will burn is very important.

In the purchase of coal, specifications may be obtained to determine B.T.U. content, quantity ash; and non-combustible materials. P.S.L.

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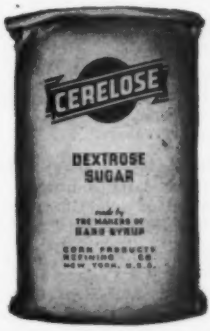

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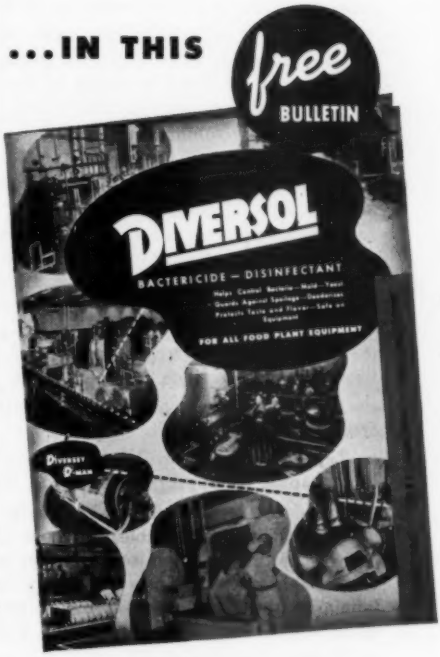

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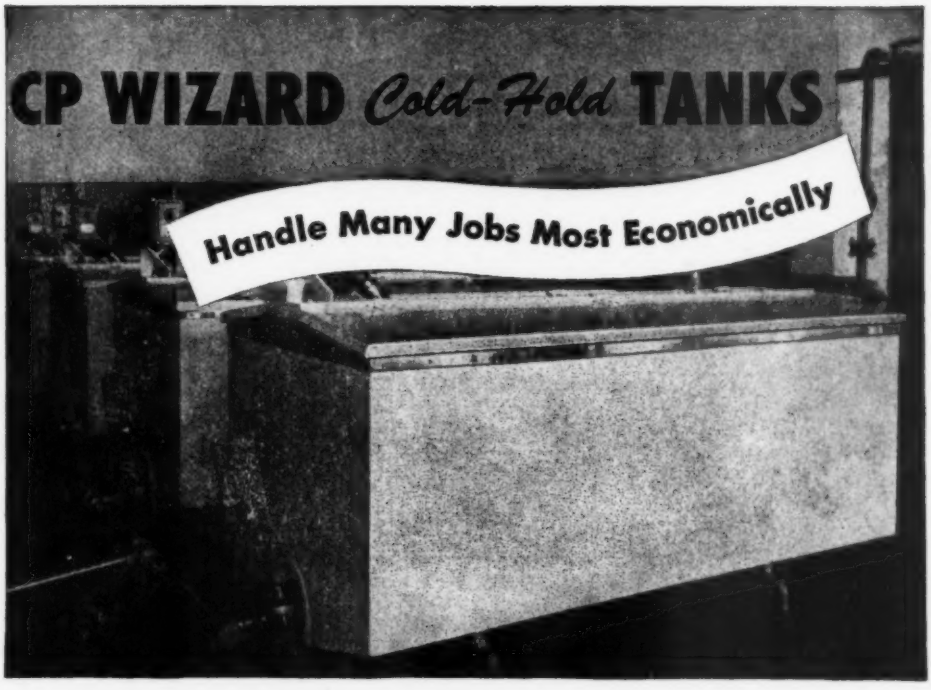

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